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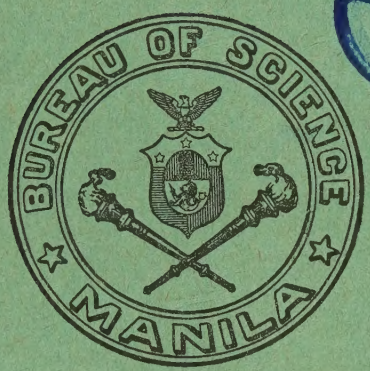

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GLEICHENIACEÆ OF NEW GUINEA

By EDWIN B. COPELAND
Of the University of California, Berkeley, California

SIX PLATES

The genus *Gleichenia*, construed, as has long been the practice, to include almost the entire family Gleicheniaceæ, is a natural genus, just as *Trichomanes* would be if made to include all Hymenophyllaceæ. But it is very diversified, and is becoming inconveniently large. It should be broken up, if the resulting genera can be likewise natural and easily recognized. This happens to be easy; and, being so, it has been done, in part, earlier but thoroughly by Presl. Christensen [1] has revived some of the old names, recognizing 5 genera. In the following treatment of the New Guinea species I follow Christensen, except for the resurrection of one more Preslian genus, *Hicriopteris*. The family then includes 2 monotypic genera with simple pinnate fronds, besides the 4 following, represented in New Guinea.

Key to the New Guinea genera of Gleicheniaceæ.

a^1. Segments minute, round or roundish..... 1. *Gleichenia.*
a^2. Segments much larger and longer.
  b^1. Fronds pectinate (once-pinnate) above highest fork.
    c^1. Veinlets several, sporangia more than 6..... 2. *Dicranopteris.*
    c^2. Veins once-forked, sporangia up to 6..... 3. *Sticherus.*
  b^2. Frond bipinnate above last fork..... 4. *Hicriopteris.*

1. Genus GLEICHENIA Smith

Frond bipinnate or more compound; segments minute, round or ovate; sori usually composed of 3 or 4 sporangia. A small genus of the Oriental Tropics and farther south. *Platyzoma,*

[1] Verdoorn's Manual of Pteridology (1938) 530.

with one Australian species, differs in having a narrowly linear frond, the segments borne on the primary rachis.

Key to the New Guinea species of Gleichenia.

a^1. Segments cucullate, with small opening beneath..... 1. *G. circinnata.*
a^2. Segments bullate, neither surface exposed.
  b^1. Lamina bearing peltate scales beneath..... 2. *G. peltophora.*
  b^2. Lamina without peltate scales..... 3. *G. squamosissima.*

1. GLEICHENIA CIRCINNATA Swartz.

Brass 12624, altitude 2,150 meters in *Sphagnum*. This speci- altitude 2,400 meters. Long reported from New Guinea. Report of *G. dicarpa* in New Guinea probably refers to what is here called *G. circinnata.*

South to New Zealand; occurrence in Philippines and Malaya is subject to confirmation.

2. GLEICHENIA PELTOPHORA Copeland.

Gleichenia borneensis (Baker) C. CHRISTENSEN, Gardens' Bull. 7 (1934) 211.

Brass 12624, altitude 2,150 meters in *Sphagnum*. This specimen has small, appressed, brown paleæ on the axes; these are found on the buds of the type collection, but are caducous or absent elsewhere.

MINDANAO, Mount Matutum. BORNEO, Mount Kinabalu.

3. GLEICHENIA SQUAMOSISSIMA Copeland sp. nov. Plate 1.

Rhizomate late repente, 2 mm crasso, castaneo, lignoso, paleis fuscis cinerascentibus deciduis subvestito; stipite 10 cm alto, 1.5 ad 2 mm crasso, deorsum castaneo mox nudo, sursum paleis cinerascentibus appressis laceris vestito, tum demum plus minusve glabrescente et asperulo; lamina usque ad 25 cm alta, rigida, erecta, bipinnata, haud furcata; rhachi ubique dense paleacea, paleis majoribus 2 ad 3 mm longis ovatis patentibus margine mox laceris albidis, minoribus et minutis appressis varie dissectis; pinnis 2 ad 4 cm longis, circa 2 mm latis, erecto-patentibus, ad costam crassam pinnatis, costa superne decidue fibrillosa, inferne paleis circa 1 mm longis ovatis acuminatis ferrugineis laceris segmenta occultantibus immersa; segmentis vix 1 mm longis latisque, compresso-contiguis, subsphaerice bullatis, superne in herbario sculpturatis.

DUTCH NEW GUINEA, Lake Habbema, altitude 3,225 meters, "covering dry ridge points on open grassland," *Brass No. 9182*, type; *No. 9082*, "Alpine grassland, covering the ground on slopes

of well drained Ridges." Also, Morobe district, altitude 9,000 to 10,000 feet, in open grassland, *Clemens 9933*.

Near *G. vulcanica* Blume, but much more scaly than the Java plant, and the main axis strictly undivided. I would not be sure by the descriptions, by Blume, or by Mettenius [2] as to the paleæ of costa; but on such Java specimens as are available it is persistently scaly only near the base, and there and on the rachis far less densely than on *G. squamosissima*.

Brass No. 4314, from Mount Albert Edward, identified by Christensen as "G. vulcanica, unbranched form," is less scaly than the plants here described, more so than those of Java. It seems to me that all New Guinea specimens known represent one species, distinct from that of Java.

2. Genus DICRANOPTERIS Bernhardi

Veinlets more than once-forked; sori of multiple (more than 6 in full fruit) sporangia; rhizome and fronds hairy or naked, not paleate; frond pinnate, or forked at top of stipe, then repeatedly forked in full development, with a pair of "stipules" subtending each forking except last forkings, only the stipules and the ultimate divisions of the frond foliaceous. A small genus if *D. linearis* is broadly construed, a fairly large genus if its many forms are treated as species. Pantropic, a little beyond the Tropic of Cancer, and south to New Zealand; not particularly developed in New Guinea.

Key to the New Guinea species of Dicranopteris.

a^1. Segments naked or practically so ..... 1. *D. linearis.*
a^2. Segments more or less rusty-felty ..... 2. *D. ferruginea.*

1. DICRANOPTERIS LINEARIS (Burm.) Underwood.

Brass 12319, altitude 1,700 meters, naked and glaucous beneath; *No. 8807*, altitude 10 to 100 meters, naked, slightly glaucous, much-branched, segments narrow. The two collections seem specifically distinct.

2. DICRANOPTERIS FERRUGINEA (Blume) Copeland comb. nov.

Mertensia ferruginea BLUME, Enum. (1828).

Brass 8961, 8980, Hollandia, altitude 20 to 100 meters. *Brass 5519*, received as *Gleichenia laevigata*, is essentially like this species as represented in Java. *G. linearis* var. *subferruginea* Hieron.,[3] from German New Guinea, New Ireland, and the Solo-

[2] Ann. Ludg. Bat. 1 (1863) 46.
[3] Engler's Jahrb. 56 (1920) 209.

mon Islands, is described as differing in that its rusty felt is broader and mostly confined to the costulæ.

3. Genus STICHERUS Presl

Sticherus PRESL, Tent. (1836) 51; CHRISTENSEN in Verdoorn, Man. Pterid. (1938) 530.

Rhizome and frond paleaceous or glabrescent; frond in typical development pinnate or bipinnate, its subsequent division pseudodichotomous, the growth of the terminal bud being suppressed above each node; foliar segments borne on ultimate axes and usually on one to three preceding internodes, nodes without stipulelike appendages; veins once-forked; sori of 1 to 6 (most commonly 4) sporangia. A large genus, throughout the Oriental and American Tropics.

The genus is distinct and easily recognizable, but its name has the least possible sanction. I have resurrected a number of Presl's names for genera founded on accidental or illusory, not to say wholly imaginary characters, always on the basis of a fixed type species. With more misgivings, I do this again, for *Hicriopteris*. But the case for *Sticherus* is weaker. Presl avowedly had seen no specimen, and mistrusted this genus even before its publication.—"Generibus quatuor notis duo alia addidi, quorum posterius a me tantum suspicatur, cum hucusque nullum specimen vidi."[4]—he ignored it later in publishing *Hicriopteris;* his diagnostic character, reticulate venation, is imaginary; and it is ambiguously typified. Two species are cited after the diagnosis, of which the first is *S. laevigatus* (*Mertensia laevigata* Willd.) ; therefore this specimen may be accepted as the type. But the other species is a *Dicranopteris,* and this happens to be the one singled out in the diagnosis as having reticulate veins. I adopt this name under the circumstances because the genus has never received another, and because Christensen precedes me in its adoption.

The ramification of the frond of the Gleicheniaceæ is altogether peculiar, only *Lygodium* having some resemblance to it. The application to this leaf of terms having a definite meaning as applied to the leaves and to the stems of other plants has resulted in confusion, and in great difficulty in the interpretation of descriptions. The fronds have commonly been said to be dichotomous; but, writing accurately, they are pseudodicho-

[4] Tentamen (1836) 47.

tomous. The bud above the apex of an internode (here we use a term usually applied to stems), representing the continuation of the axis, is suppressed, and at its sides develop a pair of axes, which are really (sub-) terminal pinnæ.

To apply to the frond plan usual in *Sticherus,* Diels [5] invented the section name *Holopterygium,* one of four sections of his *Gleichenia.* Later I added a fifth section, *Protogleichenia,* supposed to be characterized by the continued development of a series of these buds, producing a typically pinnate, or eventually bipinnate frond. Actually, of Diels's sections, *Diplopterygium* is a natural group of species, the genus *Hicriopteris; Heteropterygium* is also a natural group, a part of the genus *Dicranopteris; Acropterygium* is not such a group, but represents a frond plan found in *Gleichenia, Dicranopteris,* and *Sticherus.* And my *Protogleichenia,* as distinguished from *Holopterygium,* does not represent a group of species at all; it is a development of which very many species are capable, of which *Holopterygium* is merely an arrested state, apparently too common in herbaria, where the full development of large fronds is likely not to be shown.

At least in the Oriental Tropics, *Sticherus* in full development has bipinnate fronds. After the development of several pairs of pinnæ, and one or a few pairs of pinnules on each of them, the terminal buds cease to develop, and a series of pseudodichotomies follows. According to its degree of individual development, the frond may represent *Holopterygium* and not appear pinnate at all, or it may be once- to thrice-pinnate, and the branches may then be pseudodichotomous (strictly, still pinnate) once to as many as five times. I have confidently identified as *S. habbemensis,* presently to be described, fronds without any rachis, forked at the top of the stipe and only once more (these plants dwarfed, not juvenile), and others more typically developed, with axial, secondary, and tertiary rachises, followed by forkings. Describing species capable of such varied development, such words as pinnule are meaningless, and their use, unless they are defined for this application, is merely confusing. If I have misconstrued some published species, this is my apology, that I do not understand the terms of the descriptions.

At the end of the series of divisions, few or many, of the frond, we find uniformity. The paired axes springing from the last forking are foliose, pectinate. I term their divisions seg-

[5] Pflanzenfamilien 1 4 (1902) 333.

ments; in the descriptions they have been called variously,—segments, laciniæ, pinnules, and lobes. They are linear in most species of *Sticherus*. The axis of a segment is the costule. It bears the veins, which are uniformly once-forked in *Sticherus*. The sori are dorsal on the acroscopic veinlet, round (punctiform), small, and exindusiate. In the other genera of the family segments are borne only on the ultimate axes of the frond. In *Sticherus* they are usually produced below the last forking, most commonly on two internodes, as well as above the last node.

Key to the New Guinea species of Sticherus.

a^1. Segments ovate or broader.
  b^1. Segments under 1 cm long ..... 1. *S. bolanicus.*
  b^2. Segments 2 cm long ..... 2. *G. monticola.*
a^2. Segments narrow, commonly linear.
  b^1. Segments naked or soon glabrescent.
    c^1. Height under 60 cm, branches suberect ..... 3. *S. erectus.*
    c^2. Normally larger, branches divaricate.
      d^1. Segments green beneath ..... 4. *S. laevigatus.*
      d^2. Segments glaucous beneath ..... 5. *S. hirtus.*
  b^2. Segments setulose, at least on costules.
    c^1. Sporangia slightly impressed ..... 6. *G. Warburgii.*
    c^2. Sori superficial.
      d^1. Rachises with dense indument ..... 7. *S. caudatus.*
      d^2. Rachises paleate or glabrescent.
        e^1. Segments green beneath ..... 4. *S. laevigatus.*
        e^2. Segments more or less glaucous.
          f^1. Frond papyraceous ..... 5. *S. hirtus.*
          f^2. Frond coriaceous ..... 8. *S. habbemensis.*
a^3. Costules paleate beneath.
  b^1. Segments somewhat deflexed ..... 9. *S. reflexipinnulus.*
  b^2. Segments horizontal or ascending.
    c^1. Segments confined to ultimate branches.
      d^1. Subcoriaceous, segments 13 mm long ..... 10. *S. pulcher.*
      d^2. Coriaceous, segments 25 mm long ..... 11. *S. pseudoscandens.*
    c^2. Segments present on upper internodes.
      d^1. Segments not over 2 mm wide.
        e^1. Veins very salient beneath ..... 12. *S. venosus.*
        e^2. Veins merely evident ..... 13. *S. lamianus.*
      d^2. Segments 3 mm wide or wider.
        e^1. Paleæ on ultimate axes 3 mm long ..... 14. *S. vestitus.*
        e^2. Paleæ shorter or deciduous ..... 15. *S. Brassii.*

1. STICHERUS BOLANICUS (Ros.) Copeland comb. nov.

Gleichenia bolanica ROSENSTOCK, Fedde's Repert. 12 (1913) 16.
Gleichenia subulata VAN ALDERWERELT VAN ROSENBURGH, Nova Guinea 14 (1924) 23.

Brass Nos. 9044, 9626, 9655, 10123, altitude 3,225 to 3,700 meters, in forest and in grass. Also, *Nos. 4387, 4633,* Central Di-

vision.[6] The type is from Bolan, altitude 3,400 to 3,800 meters, represented in Herb. Univ. Calif. by a fragment and by the author's tracing.

G. subulata seems by its description to differ in no respect from the varying specimens in hand; it is from "foot of Doorman Summit," altitude 3,250 meters.

2. GLEICHENIA MONTICOLA Ridley.

Collected at the same altitude and in the same region, this appears to differ from *S. bolanicus* only in having ovate segments 2 cm long.

3. STICHERUS ERECTUS (C. Chr.) Copeland comb. nov.

Gleichenia erecta C. CHRISTENSEN, Brittonia 2 (1937) 269.

Brass 4591, 4190, Wharton range, Central Division, altitude 2,840 meters, in open grassland. I mistrust a dwarf species, but this can hardly be a stunted form of *S. hirtus.* Its firmer texture could be correlated with dwarfing, but the paleæ of its axes are uniformly more entire, and the segments are relatively long.

4. STICHERUS LAEVIGATUS (Willd.) Presl.

Long reported from New Guinea; but I have no specimens which match well those from Java.

5. STICHERUS HIRTUS (Blume) Copeland comb. nov.

Gleichenia hirta BLUME, Enum. (1828) 250.
Gleichenia dolosa COPELAND, Perkins' Fragmenta 3 (1905) 193, *pl. 4 C.*
Gleichenia amboinensis VAN ANDERWERELT VAN ROSENBURGH, Bull. Dept. Agr. Ind. Néerl. 18 (1908) 3.
Gleichenia ornamentalis ROSENSTOCK, Nova Guinea 8 (1912) 715.
Gleichenia candida ROSENSTOCK, Fedde's Repert. 5 (1908) 33.

Brass 12468, altitude 2,150 meters, "the principal species in the fern cover on a land slip in the mossy forest," the segments perfectly naked. *King 188,* Goodenough Bay, altitude 1,200 meters, segments strongly but deciduously white-setose beneath. *Schlechter 19842,* Kaiser Wilhemsland, altitude 900 meters, very slightly setose beneath, and now without paleæ on the ultimate axes. *Werner, Ros. Fil. novog. exsicc. 44,* Mount Gelu, altitude 1,700 meters, type collection of *G. candida,* perfectly naked and very glaucous beneath. *Werner s. n.,* received from Rosenstock as *G. candida* Ros. *forma, typical S. hirtus,* with deciduous, linear, strongly ciliate paleæ on the axes. *Carr 14572,*

[6] Christensen, Brittonia 2 (1937) 270.

Beridi, altitude 6,000 feet, "*Gleichenia dolosa* var. *virescens* Hieron.," typical but not very glaucous. *Brass 4924*, Mount Tafa, Central Division, altitude 2,400 meters; Christensen[7] would hold this, as *G. amboinensis*, distinct from *S. hirtus*, but I can see no difference from forms of the latter. Knowing this fern well in the field, and being familiar with its variability in single thickets, I include in it extreme forms which I would be likely to describe as distinct species if I knew them only by the extremes in the herbarium.

6. GLEICHENIA WARBURGII Christ.

Reported in New Guinea by v. A. v. Rosenburgh on the basis of *Lam 1396*, Doorman river, altitude 200 meters. I have this specimen, and do not know the species more authentically. Quite surely the same is *Werner, Ros. Fil. novog. exsicc. 54*, from Mount Gelu, altitude 1,000 meters, received as *G. laevigata* var. *bracteata* (Bl.), a name of which I do not know the origin.

7. STICHERUS CAUDATUS Copeland sp. nov. Plate 2.

Rhizomate 1 cm crasso, paleis atrocastaneis linearibus 6 mm longis, rigidis, subintegris vestito; stipite 45 cm alto, 5 mm crasso, fusco, deorsum glabrato et verruculoso, sursum indumento appresso-flocculoso tum demum deciduo vestito; fronde pinnata, pinnis bis furcatis, rhachibus indumento cinereo vestitis; gemmis dormantibus paleis castaneis 1.5 ad 2 mm longis basibus ciliatis apicibus setiformi-protractis vestitis; costis superne pilis albis crinitis vestitis, sursum glabrioribus, inferne et setis albis contortis et paleis parvis castaneis basibus ovatis ciliatis apicibus setiformibus longis ornatis; ramis ultimis 15 ad 20 cm longis, 3 ad 4 cm latis, anguste caudatis, internodio uno tantum plerumque segmentifero; segmentis adscendenti-patentibus, ob margines revolutos vix 2 mm latis, coriaceis, costulis inferne pilis albidis crinitis ornatis; soris medialibus, confluentibus, sporangiis circa 4.

DUTCH NEW GUINEA, *Brass No. 12466;* "One clump 0.75 m high, on an open rock side at 2,150 m. 18 Km. SW. of Bernhard Camp, Idenburg River."

Well characterized by its various pubescence, particularly by the dark-brown component of it. *Gleichenia caudata* Copeland, of Fiji, is a *Dicranopteris*.

[7] Christensen, Brittonia 2 (1937) 270.

8. STICHERUS HABBEMENSIS Copeland sp. nov. Plate 3.

Rhizomate 3 ad 4 mm crasso, paleis sparsis fuscis 1.5 mm longis anguste ovatis tum demum deciduis et tubercula sat magna reliquentibus vestito; stipite usque ad 80 cm alto, 3 mm crasso, castaneo, basi paleaceo alibi glabro; fronde grande, bis vel ter pinnata, deinde bis furcata, gemmis dormantibus dense, rhachibus inferioribus sparse, superioribus non dense paleis 2 mm longis lanceolatis castaneis pallide ciliatis vestitis; ramo ultimo usque ad 30 cm longo, penultimo 4 ad 6 cm longo foliaceo, proximo 2 ad 3 cm longo interdum foliaceo; segmentis horizontalibus, majoribus 2 cm longis, 2.5 ad 3 mm latis, coriaceis, inferne glaucis, margine plerumque deflexo, costula inferne et squamulis omnino dissectis et fibrillis vix persistentibus vestita, venis marginibusque setulis caducis adspersis; soris superficialibus, sporangiis 4 vel 5.

DUTCH NEW GUINEA, *Brass No. 10569*, type, 9 kilometers northeast of Lake Habbema, altitude 2,800 meters, "plentiful on wet, clayey soil of landslips;" *No. 11588*, Bele River, altitude 2,200 meters, "abundant in open second growths; erect or shortly scrambling;" *No. 9100*, Lake Habbema, altitude 3,225 meters, "abundant in moist gullies," a depauperate form, total height 20 to 80 cm, with one pair of once-forked pinnæ.

9. STICHERUS REFLEXIPINNULUS (C. Chr.) Copeland comb. nov.

Gleichenia reflexipinnula C. CHRISTENSEN, Brittonia 2 (1937) 271.

Brass 4847, Mount Tafa, Central Division, altitude 2,700 meters.

10. STICHERUS PULCHER Copeland sp. nov. Plate 4.

Fronde bipinnata; rhachi 1.5 mm crassa, castanea, paleis minutis perpaucis adspersa aliter (sub oculo nudo omnino) glabra; rhachibus secundariis gracilioribus; pinnulis infimis pectinatis, sequentibus furcatis, rhachibus tertiariis circa 2 cm longis segmentis carentibus, gemmis dormantibus minutis, ramis ultimis solummodo segmentiferis, usque ad 20 cm longis et 25 mm latis, vix ad costam pectinatis, superne glabris, costa inferne ad latera paleis inconspicuis vix 1 mm longis attenuatis ciliatis vestita; segmentis fere horizontalibus, circa 3 mm latis, apice rotundatis; subcoriaceis costulis paleis minutis sublaceris ferrugineis subdeciduis ornatis, venulis minute stellato-fibrillosis deinde glabrescentibus; soris medialibus, parvis, sporangiis plerumque 4, rarius 3 vel 5.

DUTCH NEW GUINEA, *Brass No. 12351,* "Scrambling in mossy forest seral growth at 1650 m, glaucous beneath; 15 Km SW. of Bernhard Camp, Idenburg River."

In the specimen the glaucousness is inconspicuous. The most conspicuous character of the species is the restriction of the segments to the ultimate axes. It is also remarkable for its very slender rachises.

11. STICHERUS PSEUDOSCANDENS (v.A.v.R.) Copeland comb. nov.

Gleichenia pseudoscandens VAN ALDERWERELT VAN ROSENBURGH, Nova Guinea 14 (1924) 23.

Doorman Top, altitude 2,480 meters, *Lam 1935,* in Herb. Univ. Calif. Darker, more firm, larger, and more glabrescent than *S. pulcher.*

12. STICHERUS VENOSUS Copeland sp. nov. Plate 5.

Rhizomate stipiteque 3 mm crassis, castaneis, glabrescentibus; fronde pinnata vel bipinnata, deinde ter vel quater furcata, rhachibus non segmentiferis glabrescentibus, nodis inferioribus stipulis parvis dissectis donatis, gemmis dormantibus plerisque obsoletis, ramo ultimo et internodiis 1 ad 3 segmentiferis, ramo ultimo usque ad 25 cm longo, 3 cm lato; costis paleis ovatis 0.6 mm longis sparsis mox disruptis vestitis deinde glabrescentibus; segmentis horizontalibus, 2 mm latis, apice rotundatis, margine deflexis, chartaceis; costulis inferne paleis pallidis ovatis demum fimbriatis densis et interdum complexis vestitis; venis inferne insigniter praestantibus; soris medialibus, sporangiis circa 4.

DUTCH NEW GUINEA, *Brass No. 12348,* type; "Frequent in open places in the mossy forest at 1650 m, scrambling to 2–3 m; glaucous beneath; 15 Km. SW. of Bernhard Camp, Idenburg River;" *No. 12467,* "Associated with No. 12468 (*S. hirtus*) on a landslip in the mossy forest at 2150 m up to 1 m high and of weak habit." Here also *Brass 4797,* from Vanapa Valley, Central Division, distributed as *G. laevigata.*

Conspicuously characterized by the salient venation. *G. laevigata* has fine veins and much less scaly costulæ. Still other distinct species from Borneo and the Philippines bear this name in herbaria.

13. STICHERUS LAMIANUS Copeland sp. nov. Plate 6.

Stipite ad basi 9 mm crasso, paleis rufo-castaneis usque ad 12 mm longis lanceolatis valde attenuatis subintegris immerso, sursum glabrescente, purpureo-fusco, verruculoso; fronde bi-

pinnata, pinnulis quater furcatis, ramo ultimo et internodiis dos segmenta gerentibus, gemmis dormantibus parvis vel obsoletis; ramis ultimis 20 ad 25 cm longis, 2 ad 2.5 cm latis, vix ad costas pectinatis, costa inferne paleis lanceolatis, acuminatis, 1 ad 1.5 mm longis cinereis plus minusve araneoso-marginatis ornata, apicem versus glabra; segmentis fere horizontalibus, 2 mm latis, apice rotundatis, margine leviter deflexis, papyraceo-coriaceis, inferne subglaucis, costulis paleis albidis araneoso-dissectis ornatis; soris medialibus, sporangiis 3 vel 4.

DUTCH NEW GUINEA, *Brass No. 11455,* type; "One clump in open undergrowth under oaks; erect or suberect to 2 meters. Bele River, 18 Km NE. of Lake Habbema, alt. 2350 m." Also, *Lam No. 1945,* rug near Doorman Top, altitude 2,400 meters, received as *G. ornamentalis* Rosenst. var. *lanuginosa,* det. v. A. v. R.

14. STICHERUS VESTITUS (Blume) Copeland comb. nov.

Gleichenia vestita BLUME, Enum. (1928) 249.

Reported here by Ridley;[8] I have seen no New Guinea specimen.

15. STICHERUS BRASSII (C. Chr.) Copeland comb. nov.

Gleichenia Brassii C. CHRISTENSEN, Brittonia 2 (1937) 271.

Brass 4922, Mount Tafa, Central Division, altitude 2,400 meters. Somewhat like *S. pseudoscandens* in aspect, but with light-brown scales on the dormant buds, and segments on the highest internodes.

4. Genus HICRIOPTERIS Presl

Hicriopteris PRESL, Epim. (1849) 26.

Ultimate main divisions of the frond paired and bipinnate, segments borne only on their numerous divisions; like *Sticherus* in paleæ, venation, and sori. A small genus of very large ferns, of the Tropics and northward to Japan.

This group of species is evidently a natural one, and is exceptionally easy to recognize; therefore, to leave *Sticherus* smaller and more uniform, it is expedient to regard *Hicriopteris* as a distinct genus. I adopt Presl's name on the supposition that his one species, *H. speciosa,* is really the same he described one page previously as *Mertensia gigantea,* and that his distinctive characters, twice-forked veins with marginal anastomoses, were illusions. It is my practice to identify genera by their types. In this instance I would like better to use Hasskarl's well-authenticated name, *Mesosorus,* typified by the same species, *Gleichenia*

[8] Trans. Linn. Soc. Bot. II 9 (1916) 252.

gigantea Wallich: Hooker; but I would have then to expect every species presently to be renamed.

Following the use of the term, in *Stichérus*, I call the midvein of a segment the costule, and the axis from which these spring the costæ; the costæ spring from the ultimate rachis. Peculiarly to this genus, I call that division of the frond a pinna which has the ultimate rachis as its axis; its divisions are of course pinnules, the axes of which are the costæ.

Key to the New Guinea species of Hicriopteris.

a^1. Costæ strongly scaly.
  b^1. Costæ also densely tomentose..... 1. *H. novoguineensis.*
  b^2. Costæ slightly tomentose under scales..... 2. *H. arachnoides.*
a^2. Costæ slightly and minutely scaly..... 3. *H. astrotricha.*

1. HICRIOPTERIS NOVOGUINEENSIS (Brause) Copeland comb. nov.

Gleichenia novoguineensis BRAUSE, Engler's Jahrb. 56 (1920) 210.

Described from German New Guinea; type, *Ledermann 12744*. *Brass 4960*, from Mount Tafa, Central Division, is identified as this species by Christensen.

2. HICRIOPTERIS ARACHNOIDES (Hasskarl) Copeland comb. nov.

Mesosorus arachnoides HASSKARL, Obs. Bot. (1856) 6.

Brass 12461, altitude 2,150 meters, 1 to 1.5 meters tall, conforms well with the Javan plant, already reported in New Guinea by Ridley. *Gleichenia bullata* Mett. is a distinct Bornean species.

3. HICRIOPTERIS ASTROTRICHA Copeland sp. nov.

Rhachi axiale laete brunnea, glabrata vel inferne hic illuc tomento fusco appresso maculata, 8 mm crassa, nodis superne paleis 2 ad 10 mm longis, linearibus, castaneis atrocastaneo-marginatis breviter ciliatis immersis; pinna 80 cm longa, acuta, sessile, pinnulis infimis reductis stipulas simulantibus; rhachi indumento atrofusco e paleis et amorphis et stellatis et rarius protractis composito vestita; pinnulis plerisque 10 ad 11 cm longis, basi 25 ad 28 mm latis, subsessilibus, costis superne indumento huic rhacheos simile sed paleis protractis (etsi minutis) crebrioribus vestita, inferne apicem versus glabra, alibi nisi prope rhachin glabrescente; segmentis circa 3 mm latis, infimis basi contractis, sequentibus omnino adnatis, caeteris anguste connexis, apice rotundatis, subcoriaceis, superne saturate viridibus glabris, inferne fusco-viridibus, costulis mox glabratis, venis praestantibus ubique paleis minutis castaneis stellato-dissectis ornatis.

DUTCH NEW GUINEA, *Brass No. 12129*, "Occasional under a broken canopy in the mossy forest at 1800 m, scrambling to a height of 4–5 m; glaucous beneath; 15 Km. SW. of Bernhard Camp, Idenburg River." The glaucousness is not evident in the herbarium.

Rosenstock Fil. novog. exsic. n. 33, l. Werner, Kaiser Wilhelmsland, mount Gelu, 1,000 meters, distributed as *Gleichenia longissima* Bl. var. *novoguineensis* Ros. mss., is this species, less brown and more glaucous beneath than the type, and with fewer of the minute stellate squamulæ on the veins. *H. novoguineensis* (Brause) is much more densely scaly, and without the peculiar dark stellate squamulæ on the veins.

ERRATA

Vol. 73, p. 460, insert the following after line 6:

MECODIUM LEVINGEI (Clarke) Copeland comb. nov.

Hymenophyllum Levingei CLARKE, Trans. Linn. Soc. Bot. 1 (1880) 439, *pl. 49, fig. 3.*

CHINA, Yunnan, Lung-pan-la Champutong, altitude 3,000 meters. *C. W. Wang, Fan Mem. Inst. 67117.*

Before seeing this species I hesitated to believe Clarke's description, but find it perfectly accurate. The stipe and lower part of the rachis are hairy, with multicellular hairs, the cells bearing chlorophyll like those of the lamina. Then, following up the rachis, an occasional hair is two cells wide at the base, or for any part of its length, but not to its apex. Then, some are three cells wide, and wider; until, on the upper and minor axes, some of them are lanceolate and some are ovate. In texture they are like the green lamina. By usual definition these are paleæ, but paleæ do not have this structure, and are not supposed to occur in Hymenophyllaceæ.

The affinity is to *Mecodium.* It is aberrant, there or anywhere else in the family. But a genus which already contains *M. Reinwardtii, M. exsertum,* and *M. scabrum* can find room for *M. Levingei.* There is no evident near affinity to *Myriodon, Buesia,* or *Meringium* (*Ptychophyllum*) *plicatum.*

Volume 73, p. 463, insert the following after line 24:

MERINGIUM BRYOPHILUM (C. Chr.) Copeland comb. nov.

Hymenophyllum bryophilum C. CHRISTENSEN, Brittonia 2 (1937) 274.

Distinguished from *M. Foersteri* by being much less hairy, and hardly otherwise. The isotype, *Brass 4262,* in Herb. New

York Bot. Garden, has one frond with all receptacles long-exserted.

Vol. 73, p. 465, insert the following after line 4:

MERINGIUM DENTICULATUM (Sw.) Copeland.

CHINA, Kwangsi, *C. Wang, Sun Yatsen Univ. 40602.*

My first specimen of this species from continental China.

MECODIUM PANICULIFLORUM (Presl) Copeland.

CHINA, Si-Kang, altitude 2,500 meters, *C. W. Wang, Fan Mem. Inst. 65447.*

Reported several times from China, but this is my first specimen.

Vol. 73, p. 467, insert the following after line 37:

CEPHALOMANES SUMATRANUM (v.A.v.R.) Copeland.

Hainan, *S. K. Lau, Sun Yatsen Univ. 28042.*

Previously known from Annam.

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Pages 153 and 155: *For* Holttumia in the title, in the text, and in the illustration, *read* Holttumiella.

Page 153, line 4 of text: *For* illus, *read* illuc.

ILLUSTRATIONS

[All plates are from photographs by W. C. Mathews of the types in the herbarium of the author.]

PLATE 1. *Gleichenia squamosissima* Copeland sp. nov.
PLATE 2. *Sticherus caudatus* Copeland sp. nov.
PLATE 3. *Sticherus habbemensis* Copeland sp. nov.
PLATE 4. *Sticherus pulcher* Copeland sp. nov.
PLATE 5. *Sticherus venosus* Copeland sp. nov.
PLATE 6. *Sticherus lamianus* Copeland sp. nov.

PLATE 1. GLEICHENIA SQUAMOSISSIMA COPELAND SP. NOV.

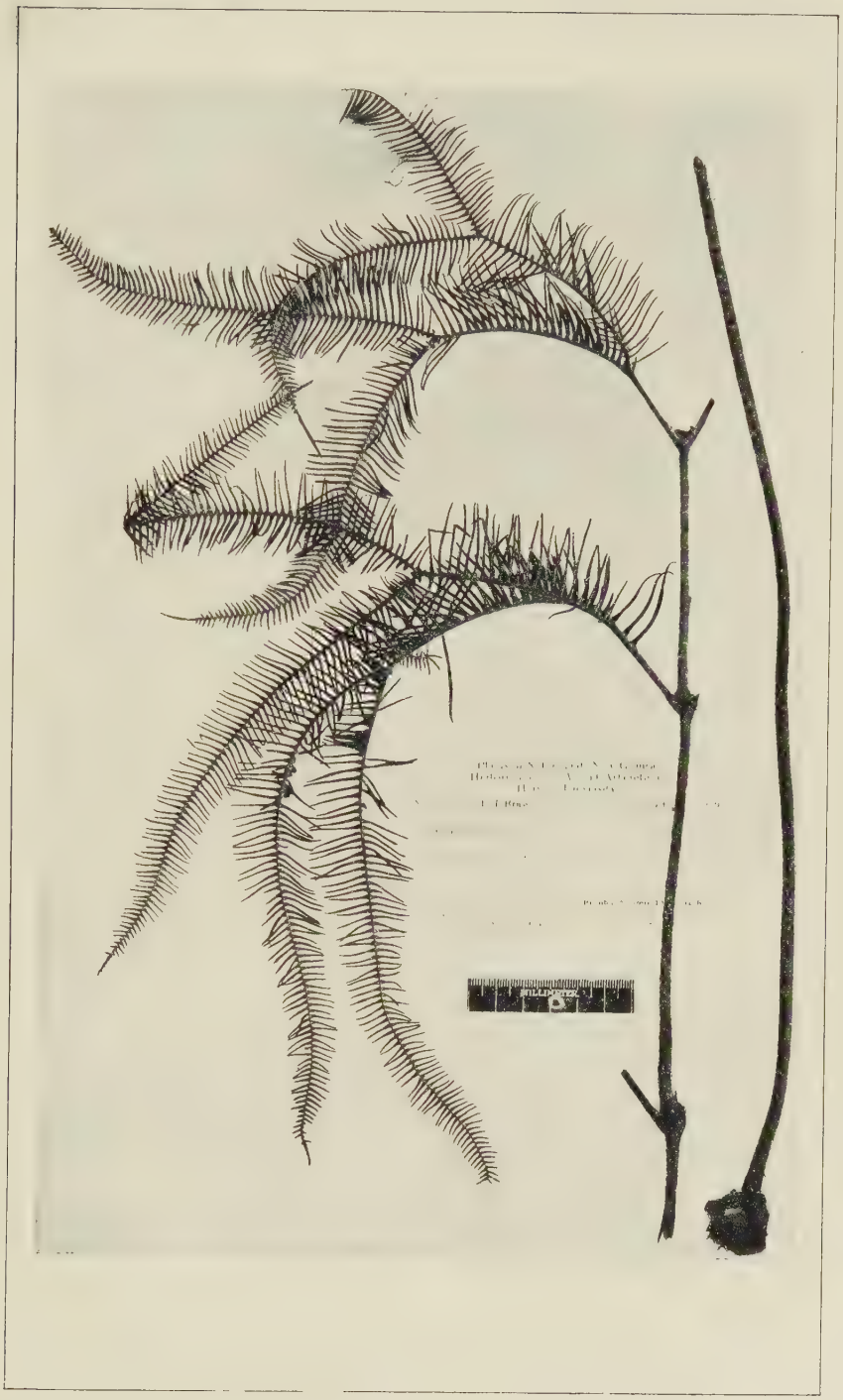

PLATE 2. STICHERUS CAUDATUS COPELAND SP. NOV.

PLATE 3. STICHERUS HABBEMENSIS COPELAND SP. NOV.

PLATE 4. STICHERUS PULCHER COPELAND SP. NOV.

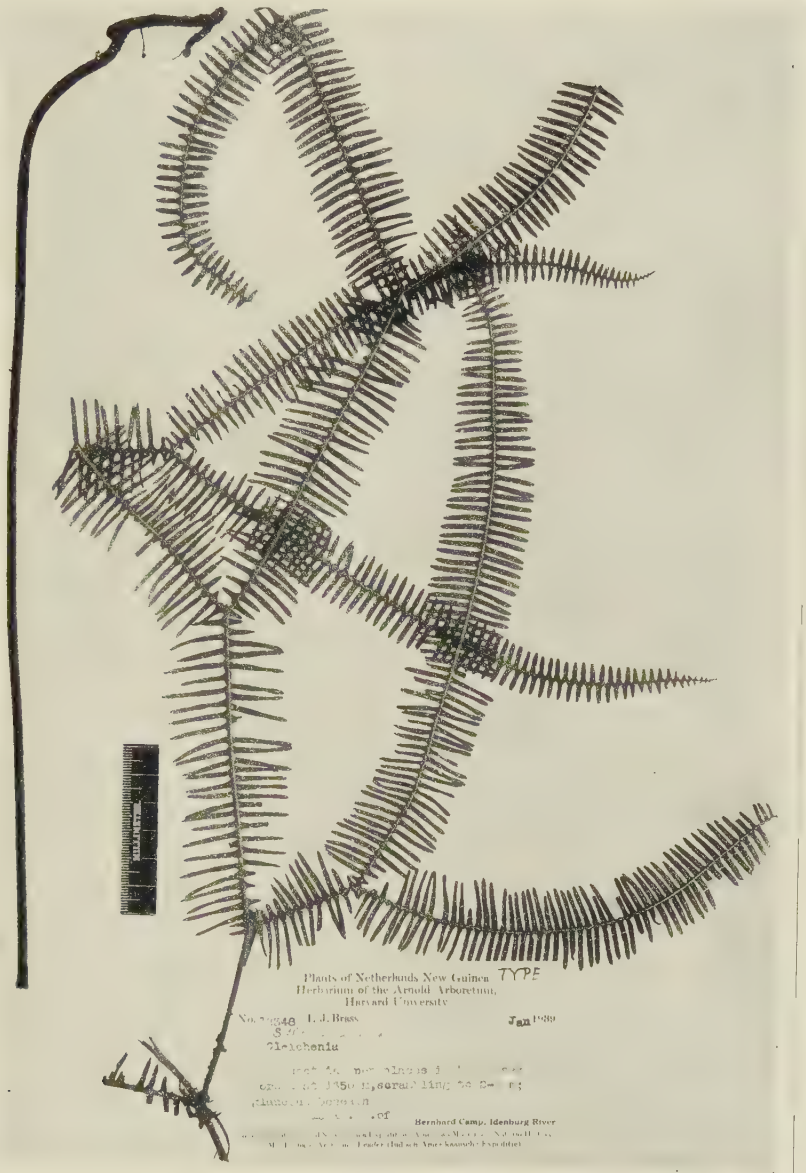

PLATE 5. STICHERUS VENOSUS COPELAND SP. NOV.

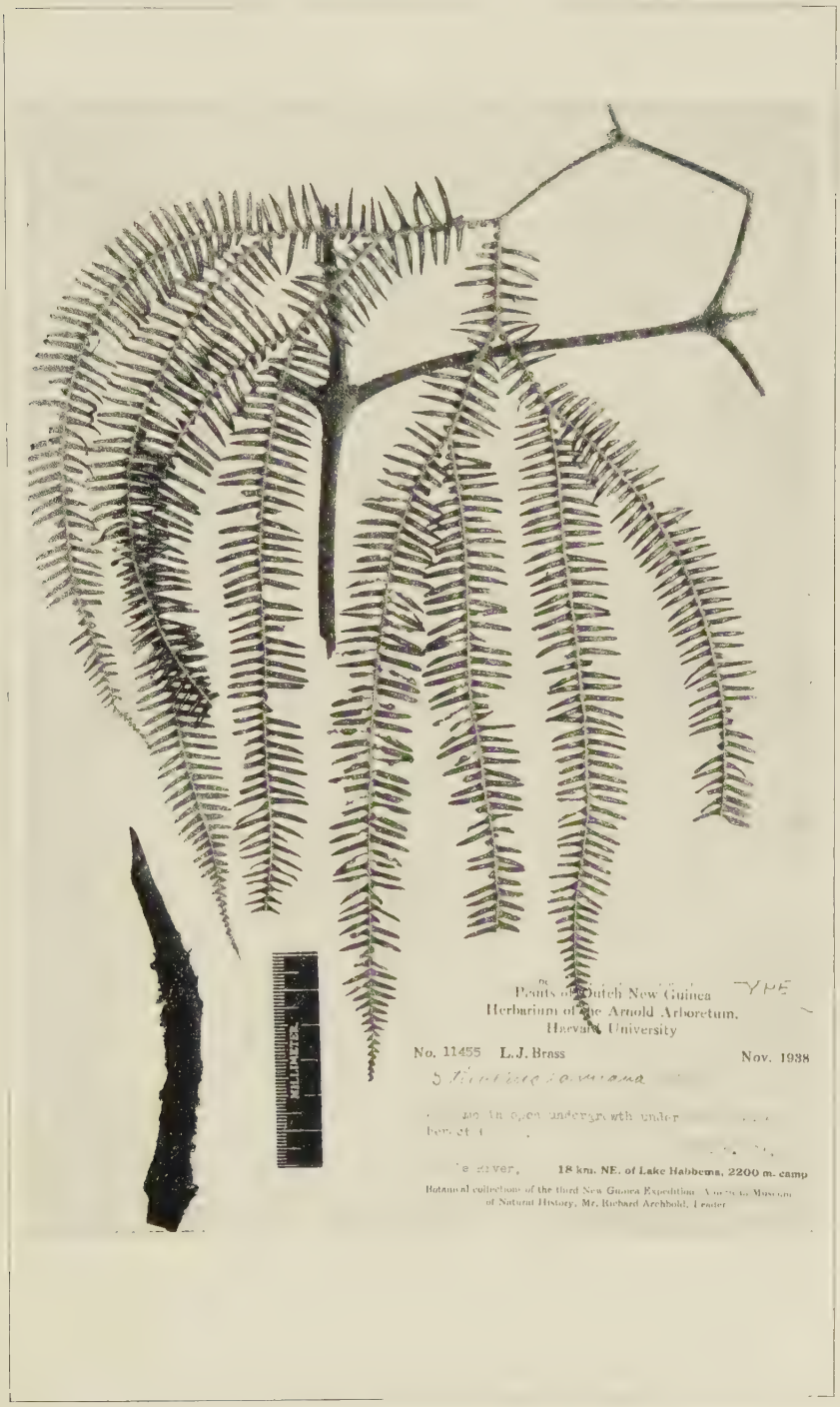
Plants of Dutch New Guinea
Herbarium of the Arnold Arboretum,
Harvard University
No. 11455 L. J. Brass
Nov. 1938
18 km. NE. of Lake Habbema, 2200 m. camp
Botanical collections of the third New Guinea Expedition

PLATE 6. STICHERUS LAMIANUS COPELAND SP. NOV.

TANNIN FROM KERNELS OF GREEN BETEL NUTS

By Luz Baens

Of the Bureau of Science, Manila

Although there are a number of tanneries in the Philippines, the annual importation of leather and leather articles amounts to about three million pesos.[1]

For the last few years the possibility of utilizing Philippine vegetable tanning materials for the manufacture of leather[2] has been studied. In the course of this investigation it was found that the kernels of green betel nuts (*Areca catechu* Linn.) contain a considerable amount of tannin which gives a leather of fine natural color.[3] Because of the excellent quality of this leather the investigation of betel-nut tannin has been continued. Recent results are recorded in this paper.

The betel-nut palm (*Areca catechu* Linn.)[4] is known in the Philippines as *boñga, buñga,* or *luyos.* Beccari[5] states that out of the 36 species of *Areca* known to him no less than 10 are very characteristic Philippine palms. A variety of *Areca catechu* (var. *silvatica*) has been found as a forest plant in Palawan. *Areca catechu* (var. *longicarpa*) is also a wild plant in Polillo. These species are probably native Philippine plants.

Areca catechu[6] is a graceful, tall-stemmed palm usually reaching a height of 60 feet; the stem is cylindrical, with a diameter of 5 to 8 inches and ringed distinctively from the base upward by the scars of fallen leaves. The young stem is green, and the old, grayish. The strong roots which grow out above the base maintain the erect position of the palm. When grown under the best conditions it begins to flower in about 4 years.

[1] One peso equals 50 cents United States currency.

[2] Baens, Luz, and A. P. West, Philip. Journ. Sci. 47 (1932) 467; Baens, Luz, F. M. Yenko, and A. P. West, Philip. Journ. Sci. 55 (1934) 177; Yenko, F. M., and Luz Baens, Philip. Journ. Sci. 61 (1936) 415.

[3] Baens, Luz, F. M. Yenko, and A. P. West, Philip. Journ. Sci. 55 (1934) 177.

[4] Blätter, E., Palms of British India and Ceylon (1926) 47.

[5] The Palms of the Philippine Islands, Philip. Journ. Sci. 14 (1919) 295.

[6] Sands, W. N. Observation on the betel-nut palm (Areca catechu, L.) and betel-nuts. Malayan Agri. Journ. 14 (1926) 202.

According to Grist [7] the plant grows well in places with evenly distributed rainfall. The seeds are first planted in a nursery and transferred after 6 to 18 months.

Stirrup [8] says that the most suitable planting distance is 8 by 8 feet, giving a stand of 680 trees per acre or 1,680 trees per hectare (1 hectare equals 2.47 acres). The average number of nuts in a bunch is 200. A young palm may bear 5 or 6 bunches annually, while an older palm may have only 1 or 2 bunches.

In the Philippines the kernels of the ripe nuts are generally used for chewing. They are usually combined with betel-vine leaf (*Piper betle* Linn.), a little lime, and tobacco. The chewers claim that chewing betel nut prevents decay of the teeth, although it leaves red stains on the enamel.

While there are no regular betel-nut plantations in the Philippines, these trees are widely distributed throughout the country. In some districts they are grown in fairly large numbers. The price of the green and ripe nuts is about the same. Usually it varies from 0.05 to 0.20 peso per 100, depending upon the supply and demand.

The tannin in betel nuts is located almost entirely in the kernel. The outside husk has only traces. As the green nut ripens, the tannin in the kernel decreases. Tests showed that the ripe kernels have only about half as much tannin as those of full-grown green nuts collected from the same tree. The highest tannin content is attained when the kernel is just about reaching maturity while the outside husk is still grass green.

Analyses of the kernels of full-grown green betel nuts from different districts showed that the tannin in them varied from 12.98 to 26.89 per cent. The high percentage suggested them as a promising source of commercial tanning material.

A composite sample of dried kernels of green betel nuts from a single tree gave the analysis recorded in Table 1. This full-grown fruit, which was about 4 months old, contained 20.16 per cent tannin. Betel-nut tannin compares favorably with other commercial tanning materials.

TABLE 1.—*Analysis of dried kernels from green betel nuts.*

Constituents.	Per cent.
Total solids	32.19
Soluble solids	29.67
Nontannins	9.51
Tannins	20.16

[7] The betel nut industry. Malayan Agri. Journ. 14 (1926) 219.

[8] The betel nut industry in the Muar Distinct, Johore. Federated Malay States Agri. Bull. 5 (1917–1918) 189.

Another composite sample of full-grown green betel nuts was obtained from Pagsanjan, Laguna Province, and used in preparing solid tanning extracts as follows: The nuts were opened and the kernels cut into small pieces. The material was extracted several times with water at 70°C. The combined liquid extracts were evaporated under reduced pressure at 70°C. until the concentration of the liquid was such that it solidified upon cooling.

Data on the extraction are:

Number of nuts used	10,073
Weight of nuts	366 kilograms
Weight of moist kernels	124.75 kilograms
Moisture in kernels	75.51 kilograms
Weight of dry kernels	49.24 kilograms
Weight of solid extract	15.56 kilograms
Extract in whole nuts	4.25 per cent
Extract in dry kernels	31.60 per cent

Assuming that a hectare can be planted with 1,680 trees, and that each tree gives annually an average of 3 bunches containing 200 nuts each, the yield of solid extract may be estimated as follows:

1 palm gives 600 nuts
1 hectare (1,680 palms) should bear 1,008,000 nuts
10,073 nuts yield 15.56 kilograms solid extract
1 hectare (1,008,000 nuts) should yield 1,556 kilograms of solid extract

In preparing the tanning extract the solution was evaporated until it contained only a small amount of moisture. When placed in a vacuum oven the bottom portion (sample B) solidified. The top portion (sample A) separated out as a coarse powder. About four-fifths of the entire extract was contained in sample B.

Analysis of the betel-nut extract described above is compared with that of the extract from Philippine bakauan bark (cutch) in Table 2. Analyses [9] of imported tanning materials (oak, hemlock, chestnut, and myrobalan) are also included.

The results (Table 2) show that betel-nut extract compares favorably with cutch and also with imported commercial tanning materials (oak, hemlock, chestnut, myrobalan).

Goatskins and sheepskins tanned with betel-nut extract in our laboratory have a fine, smooth grain and a natural light color.

[9] Baens, Luz, Leon G. Alejo, and V. G. Lava. Philip. Journ. Sci. 72 (1940) 451.

TABLE 2.—*Analysis of betel-nut extract and other tanning materials.*

Constituent.	Betel-nut extract.		Cutch.	Oak.	Hemlock.	Chestnut.	Myrobalan.
	A.	B.					
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Total solids	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Soluble solids	94.50	95.41	99.18	94.18	94.74	97.43	88.56
Insoluble solids (by difference)	5.50	4.59	0.82	5.82	5.26	2.57	11.44
Nontans	29.16	28.45	23.86	40.77	30.92	29.85	32.97
Tannins (by difference)	65.34	66.96	75.32	53.41	63.82	67.58	55.59
Ash	5.03		5.20				
Moisture content before calculating on a moisture-free basis	14.91	13.91	23.51	12.18	10.10	11.61	19.05

NOTE.—Results calculated on a moisture-free basis.

Tests on the betel-nut extract were made at the Philippine Cutch Corporation (Zamboanga) before the company was transferred to Borneo. Mr. Geo. A. Kerr, vice president and general manager of the company, said that sheepskin leather made with our betel-nut extract was about the finest light leather tannage he had ever seen. He also stated that he had treated some extracts chemically to produce a similar color, but he did not find any that gave such a fine natural color as that of the betel nut. He further assured us that this extract had a bright future for extensive use in tanning light leather from goat skins and sheepskins because of the fine natural color. Bleaching or any chemical treatment before dyeing is not necessary when betel-nut extract is used. For bookbinding and fine light leather, he considered this extract an ideal vegetable tannin material.

SUMMARY

Betel-nut palms are grown throughout the Philippines. They bear fruits about 4 years after planting. The fruit matures usually in about 6 months.

The tannin in betel nuts is located almost entirely in the kernel. The outside husk has only traces of tannin. As the green nut ripens the tannin in the kernel decreases. Ripe kernels have only about as much tannin as those of full-grown green nuts collected from the same tree. The highest tannin content is attained when the kernel is just about reaching maturity and while the outside husk is still grass green.

The kernels of full-grown green betel nuts from different trees gave a tannin content that varied from 12.98 to 26.89 per cent.

When betel-nut trees are grown 8 feet apart in plantations there are 1,680 trees to the hectare. Our results show that 1,556 kilograms of solid betel-nut extract may be produced from one hectare (1,680 trees).

The solid betel-nut extract contained 65.34 to 66.96 per cent of tannin. In composition it compares favorably with cutch (extract from bakauan) and also with foreign extracts (oak, chestnut, hemlock, and myrobalan). For light leather tannage the quality is excellent.

Goatskins and sheepskins tanned with betel-nut extract have an unusually smooth grain and a fine natural color.

The investigation indicates that the production of tanning extract from betel nuts grown in plantations has promising prospects.

ACKNOWLEDGMENT

The author wishes to thank Mr. F. M. Yenko, of the Lissar Company, Manila, and Dr. Augustus P. West, of the Bureau of Science, for suggestions and assistance in this work.

STUDIES ON THE BIOLOGY OF THE AMOY AMPHIOXUS BRANCHIOSTOMA BELCHERI GRAY

By T. G. Chin

Of the Marine Biological Station, National University of Amoy, China

FIVE PLATES AND EIGHTEEN TEXT FIGURES

Because of the present war waged by the Japanese in China the National University of Amoy, originally located near the famous amphioxus grounds in the port of Amoy, has been moved inland. The studies on the biology of the Amoy amphioxus, which had been carried on for a number of years, were consequently interrupted. It seems advisable, at this moment of uncertainty, to publish the available data so far gathered.

The systematic position of the Amoy amphioxus has already been carefully ascertained by several authors, (3, 42) all of whom gave it the specific name of *Branchiostoma belcheri* Gray, although there may be slight differences in the minute characters of the various specimens studied.

Recently Tchang and Koo (42) collected some amphioxus from Tsingtao, which was described as a new variety of *B. belcheri*, found in Amoy and its vicinity. Since it usually, but not always, has 2 or 3 more myotomes in the preatriporal region, this amphioxus is referable to *Branchiostoma belcheri* var. *tsingtauensis*.

The writer is indebted to Dr. T. Y. Chen, the Director of the Marine Biological Station, and the Head of the Department of Biology, the National University of Amoy, under whom a part of the present work was carried on, and also for his continuous encouragement and valuable criticisms during this study; to Dr. H. T. Chen, the Head of the Department of Biology, Lingnan University, Canton, for his valuable suggestions and criticisms, and for his kindness in reading the entire manuscript. The writer wishes also to express his thanks to Mr. Chih-tuh Chen, formerly technician of the Biological Supply Service, University of Amoy, for his assistance in measuring about 100,000 individual specimens for the study of the rate of growth of this amphioxus.

HISTORY

Apparently the first man to have secured specimens of *Amphioxus* for systematic study was a German zoologist, P. S. Pallas, who received a single example from his friend who collected it from the Cornwall Coast. Pallas named this animal *Limax lanceolatus*, believing that the specimen was an elongated *Limax* of the phylum Mollusca. In 1834 an Italian zoologist, G. Costa, collected amphioxus from the Posilippo Coast. He named it *Branchiostoma lubricum*, believing it to be related to the cyclostomes (Cyclostomata). In 1836 an English zoologist, W. Yarrell, renamed it *Amphioxus lanceolatus*. After these incidents numerous articles about amphioxus appeared in various journals and publications.

According to Chen (5) the history of the Amoy amphioxus may be briefly given as follows:

In the Tan Dynasty (616–905 A. D.) Han Yü killed many crocodiles at Chao Chow, Kwantung Province, but one of the wounded escaped to Amoy. After some time it died, and "maggots" from the carcass gradually changed to amphioxus. The amphioxus was, therefore, called "crocodile fish" or "crocodile maggot" by some people. This is the oldest record of amphioxus, and it indicates that the Amoy amphioxus had been known for more than one thousand years.

In the Sung Dynasty (960–1276 A. D.) Chu Hsi came to this district and "killed" the "Crocodile" Island in the front of Liuwutien with his "red pen." A piece of stone from that Island which was dropped into the sea was believed to have given rise to the numerous specimens of amphioxus borne in the sand. This information suggests that the Amoy amphioxus was known at least five hundred years ago.

At the end of the Ming Dynasty (1368–1643 A. D.) Chen Cheng-kung came to Amoy, but found insufficient food for his navy. One of the things he did was to pour several bowls of cooked rice into the sea, after which numerous individuals of amphioxus appeared floating on the water. These animals were then less used as food by Chen and his navy, hence the name of "rice fish" for amphioxus. If this is true, the history of amphioxus extends back more than three hundred years.

Besides the "crocodile fish" and "rice fish" described above for amphioxus in Chinese, there are still five other names commonly used by the natives in Amoy and its vicinity, namely: *'Wen Tsu Yü'*, *'Pien Tan Yü'*, *'Yin Chang Yü'*, and *'Wen Shen Yü'*.

'Wen Tsu Yü' is probably derived from the name of a small marine fish mentioned in ancient Chinese literature, 'Yu Pien.' This name is commonly used at Chipbee and in Tung An districts.

'Pien Tan Yü' means 'carrying-pole fish,' since the amphioxus resembles the carrying pole used in Amoy, which is a stick of wood, broad in the middle and narrow at both ends.

'Yin Chien Yü' means 'silver-spear fish,' so called because the amphioxus is very much like the silver-colored Chinese spear blade, which is probably the best name for amphioxus in Chinese.

'Ying Chang Yü' is derived from *'Yin Chien Yü.'*

'Wen Shen Yü' is the commonest name in Chinese, and means literary-composition fish.' The derivation of *'Wen Shen'* is quite obscure. It can explained in four different ways. Firstly, *'Wen Shen'* is the name of a star. Secondly, *'Wen Shen'* is the name of the God of Literature in Chinese mythology. It is said that the God of Literature rode on the back of a crocodile, which later died and the body gradually was decomposed into the "fish of the God of Literature.' Lastly, the sound of *'Wen Shen'* is closely related to *'Yin Chien.'*

In spite of the above-mentioned records the Amoy amphioxus was not known to the scientific world until Prof. S. F. Light, formerly Professor of Biology of the National University of Amoy, published his amphioxus fisheries in Science and in The China Journal in 1923. He pointed out the inexhaustible supply of amphioxus near the University of Amoy, and described in general the methods of fishing amphioxus. After this announcement numerous orders were sent to the University for these important and rare animals. Many people also came to Amoy to visit the amphioxus fishing grounds.

In 1929 Rathbun described some crabs collected from the amphioxus grounds. In 1930 C. Ping mentioned the Amoy amphioxus in his paper and called it *Branchiostoma lanceolatus.* In 1931 T. Y. Chen described a hermaphroditic amphioxus from Amoy. In the same year, C. D. Reeves published notes on the ecology of this animal as well as on the nature of its atrium and atriopore. In 1932 Boring and Li described some of the characters of the Amoy amphioxus with reference to its systematic position, and regarded it as belonging to *Branchiostoma belcheri* Gray. In the same year E. Hartmann wrote some notes on the conditions prevailing at the amphioxus fishing grounds. In 1933 T. Y. Chen and T. G. Chin made a survey of the amphiox-

us fisheries. In 1934 J. G. Ling wrote a short article about the fisheries. In the same year K. S. Lou made a careful chemical analysis of the Amoy amphioxus. In 1935 C. Liu and W. T. She made an analysis of the sea water of Amoy Harbour, a part of the analysis being related to the amphioxus ground. In the same year S. Y. Koo wrote a short article on the variation of the velar tentacles of the Amoy amphioxus. In 1936 T. Y. Chen compiled the data on the history of the Amoy amphioxus from the natives of southern Fukien Province. In the same year S. Tchang and K. C. Koo published the systematic position of the Amoy amphioxus, and confirmed the previous identification of *Branchiostoma belcheri* Gray. In 1939 T. G. Chin published a list of diatoms found in the intestine of adult amphioxus, and in the same year published some polychæte annelids collected from the amphioxus ground.

SOME STRUCTURES OF THE AMOY AMPHIOXUS

The morphology of the amphioxus has been extensively worked out by various authors, especially Goodsir, J. Müller, and H. Rathke. The present treatment is particularly concerned in some of the structures indicating the systematic position of the Amoy amphioxus and other interesting phenomena observed, such as the regeneration of the tail region, the branch cirrus, the hermaphroditic amphioxus, and the abnormal gonads.

Length.—The smallest individual seen with fully grown gonads is 29 mm long, and the largest, 57 mm, while the average fully-grown amphioxus is from 42 mm to 47 mm long. The detailed measurements of the length of the Amoy amphioxus will be discussed later in the study of its rate of growth. Fifty individuals were carefully measured for the three regions; namely, the preatrioporal, preanal, and postanal regions. The measurements and their ratio are shown in Table 1.

TABLE 1.—*Length of three regions in amphioxus and their ratio.*

Region.	Length.		
	Average.	Range.	Ratio.
	mm.	*mm.*	*mm.*
Preatrioporal	29.7	25.0–35.0	69.40
Preanal	9.7	8.0–12.0	22.66
Postanal	3.4	2.5– 5.0	7.94
Total	42.8	35.5–52.0	100.00

Number of myotomes.—The number of myotomes is variable in different individuals even of the same size. However, their number is characteristic for the species. The myotome formula of the present species is shown in Table 2.

TABLE 2.—*Number of myotomes in amphioxus.*

Region.	Average.				Range.			
	Present author.	Boring & Li.	Tchang & Koo.	Franz.	Present author.	Boring & Li.	Tchang & Koo.	Franz.
Preatrioporal	38	37	36	37	36–39	35–38	34–39	37–38
Preanal	17	17	28	17	16–18	16–18	----	16–19
Postanal	10	10	----	10	9–11	8–11	27–30	9–10
Total	65	64	65	64	63–66	62–65	62–66	63–66

The figures in Table 2 show clearly that the total number of myotomes of the Amoy amphioxus, counted by various authors, is very much the same; that is, 64 or 65. This number is within the range of myotomes for *Branchiostoma belcheri* Gray in Franz's "Systematische Revision der Akranier."

Number of gonads.—The number of gonads is not always correlated to the length of the animal, and is usually one, two or three less on the left side than on the right. The number of gonads is shown in Table 3.

TABLE 3.—*Number of gonads in amphioxus.*

Region.	Present author.		Boring & Li, range.	Tchang & Koo, range.	Franz, range.
	Average.	Range.			
Left side	25	22–28	25–28	24–27	24–28
Right side	27	23–29	----	25–29	26–30
Total	52	45–57	50–56	49–56	50–58

Number of cirri.—The number of cirri is the same on both sides of the body, although it may vary among different individuals. It is less in young forms. The number of cirri of larger specimens counted by the present author and others is shown in Table 4, which shows that the figures are closely similar.

TABLE 4.—*Number of cirri in amphioxus.*

Region.	Present author.	Boring & Li.	Tchang & Koo.	Franz.
Average	42	----	50	52
Range	36–50	44–50	44–56	----

Number of fin rays.—The fin rays of amphioxus may be divided into two kinds, dorsal and ventral. The dorsal type may be subdivided into preatrioporal, preanal, and postanal. The number of fin rays varies among different individuals, as shown in Table 5. The number of fin rays given by the present author and Tchang and Koo is the same, but differs from Franz's record. This character, as the present author believes, is not very important.

TABLE 5.—*Number of fin rays in amphioxus.*

Fin ray.		Present author.		Tchang & Koo.	Franz.
Dorsal	Preatrioporal	222–298(240)	313	305–338(321)	280
	Preanal	38–82 (66)			
	Postanal	2–13 (7)			
Ventral		35–90(72)		76–94(83)	65

Number of velar tentacles.—The number of velar tentacles is variable as are many other characters. Their variations are related to the age of the amphioxus; the younger the specimen the less the number of velar tentacles, without relation to sex.(22) The number of velar tentacles is shown in Table 6.

TABLE 6.—*Number of velar tentacles in amphioxus.*

Author.	Average.	Range.
Koo	17.5	11–22
Tchang and Koo	16.0	11–20

Regeneration of amphioxus.—In spite of the fact that amphioxus is a primitive chordate, the power of regeneration is rather limited. If any part of the body of amphioxus is injured it does not regenerate, due to the presence of numerous ciliates. Numerous individuals of amphioxus were examined during the study of growth, and only one specimen was found to represent the regenerated form.

The regenerated part of the individual under consideration is the postanal region, which is smaller and shorter than in the normal individual. The difference is shown in Table 7.

TABLE 7.—*The length of the normal postanal and of the regenerated postanal regions in amphioxus.*

Region.	mm.
Normal	3.4
Regenerated	1.6

The myotome number is the same in the regenerated specimen as in a normal individual, and the thickness and the length of

each myotome is therefore reduced to less than half the original size. The upper arch of the postanal region is in a straight line, while the lower arch is concave or enlarged at the middle. Between the preanal and the postanal region there is a depression, which indicates the regenerated point. Besides these, there is also a peculiarity in the fin rays. A normal specimen usually has 7 fin rays, while in the regenerated postanal region not a single fin ray can be found. Being skeletal in structure, the fin rays perhaps cannot regenerate. Text fig. 1 shows a regenerated tail.

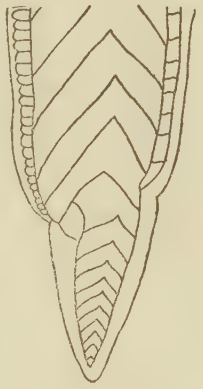

Fig. 1. The regenerated tail.

Aside from this single case of natural regeneration, experimental work leading to artificial regeneration was tried, but not a single specimen showed any sign of regeneration.

Branched cirrus.—One branched cirrus was found. The number of cirri on the same specimen was 23 on the left side and 22 on the right. One of the cirri from the right was branched into two. The branched cirrus is of normal length, but divides midway into two equal cirri, the cartilaginous skeleton within which it was found also being branched into two to conform to the external appearance. Text fig. 2 shows the branched cirrus.

The branched cirrus is either due to the union of two cirri at the base or to failure of these cirri to separate during embryological development.

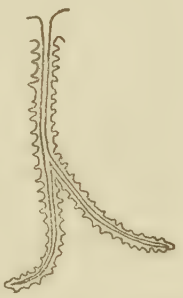

Fig. 2. The branched cirrus.

Abnormal-sized gonads.—The usual number of gonads is 52, while an abnormal male amphioxus contained only 11 testes altogether, 5 on the left side and 6 on the right. This kind of abnormality is very rare, having been found so far in only one specimen. The testes lie at the posterior half of the atrium and occupy only $\frac{3}{5}$ of the cavity.

The first and the third testes on the left side are poorly developed. They are thin and small, but the rest are unusually enlarged, into 3 to 5 times the size of the normal testis. The other 6 testes on the right side are more or less uniform in size and are nearly twice as large as the normal testis. Table 8 shows the arrangement of testes in the abnormal specimen.

TABLE 8.—*The arrangement of testes in the abnormal amphioxus.*

Side.	Number of testes. (*T*, unusually developed testis; *t*, poorly developed testis; O, no testis or gonad.)																			
Left	O	O	O	O	O	O	O	O	O	t	t	T	T	T	T	t	t	t	T	T	T	T	T	T	T	O
Right	O	O	O	O	O	O	O	O	O	O	O	O	O	O	T	T	T	T	T	T	O	O	T	T	T	T

This unusual enlargement is most likely due to reduction of the other testes. This phenomenon is also uncommon among other living organisms, and the present record is the first for amphioxus. Text fig. 3 shows the abnormal gonads.

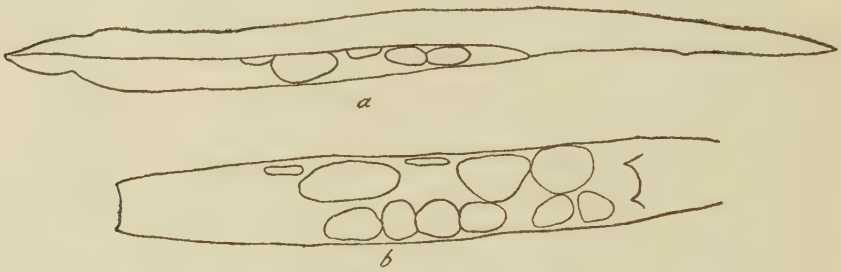

FIG. 3. The abnormal gonads. *a*, lateral view; *b*, ventral view.

Hermaphroditic amphioxus from Amoy.—The hermaphroditic amphioxus has been reported from many localities. In 1876 Langerhans detected the tails of spermatozoa among young ovaries of amphioxus. In 1912 Goodrich found a hermaphroditic specimen from Naples, containing one egg pouch on a male specimen. In 1914 Orton also described a male specimen containing one egg pouch from Plymouth. In 1922 Riddell described another case. And in 1931 T. Y. Chen, of the University of Amoy, described a specimen of the Amoy amphioxus containing equal numbers of ovaries and testes.

The hermaphroditic specimen from Amoy is an extraordinarily beautiful find, due to the arrangement of the creamy-white testes and the lemon-yellow ovaries. Table 9 shows the arrangement of testes and ovaries in the hermaphroditic amphioxus seen.

TABLE 9.—*Arrangement of testes and ovaries in an hermaphroditic amphioxus.*

Side.	T, testis; O, ovary; —, no gonad.
Left	T T T O T O O T T O — — — — T T O O T O O O O T
Right	T — T O O T T O T T O — — — — O O O O T O T T O T

FIG. 4. Map of Amoy and its vicinity, showing the currents in ebb tide (⟶), flood tide (⟵), and fresh water (- - →) from inland, the depth of the sea in meters; and the Amoy and Quamoy amphioxus grounds.

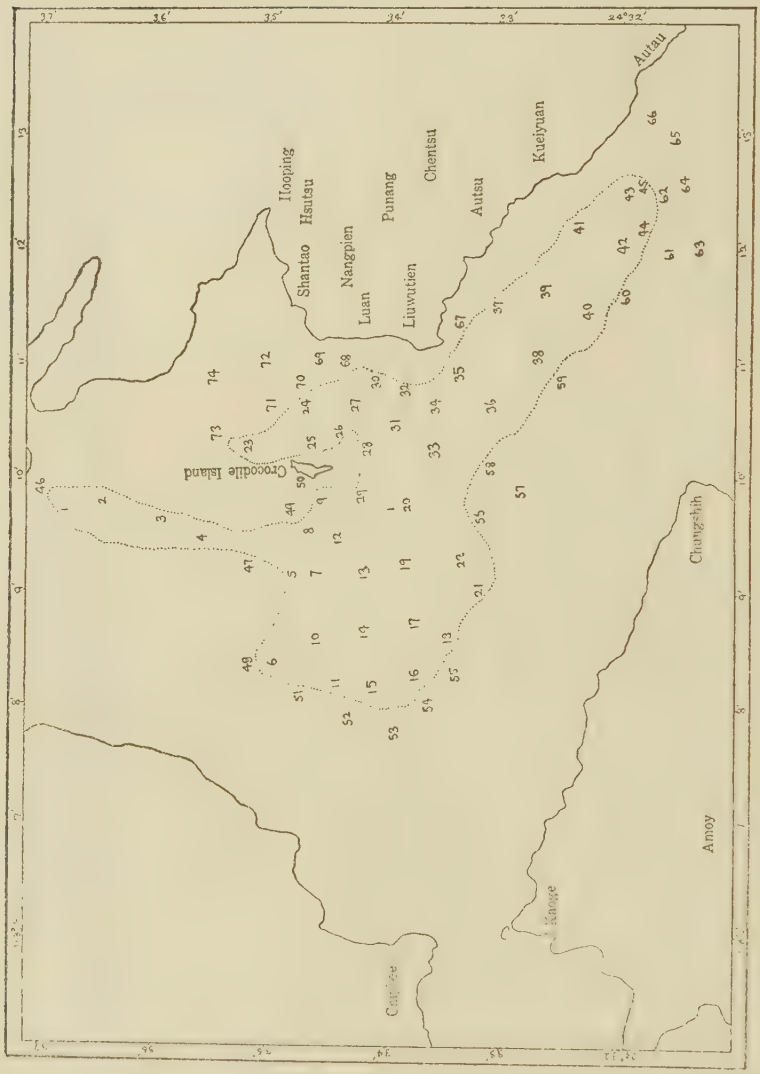

FIG. 5. Map of Amoy amphioxus grounds, showing the station numbers and the fishing villages.

ECOLOGICAL STUDY OF AMOY AMPHIOXUS GROUNDS

Amoy is located along the southeastern coast of China, between the North Temperate and Subtropical zones. The primitive chordate amphioxus has therefore found its best home there.

FIG. 6. Map of Amoy amphioxus grounds, showing the distribution of the number of amphioxus in a 1,000 cc sand sample in each station.

The species is abundant, 35 tons being captured yearly. Hence the study of the physical, chemical, and biological conditions of the ground is not only interesting but also of practical importance.

The exact amphioxus grounds are on the mainland, to the north of Amoy Island, very near a small town called Liuwutien. The area of the grounds is approximately 9 square miles.

The present survey was made in June, 1932, in a motor boat and a small native fishing boat. Seventy-four stations were studied. Text figs. 4, 5, and 6 show maps of Amoy and vicinity, the stations, and the distribution of amphioxus.

PHYSICAL CONDITIONS

Size of bottom particles.—The method of measuring the size of particles from the amphioxus ground is by drying in the sun a bottom sample of 1,000 cc from each station. Then the sample is allowed to pass through a set of sieves,[1] consisting of eight different grades, namely, particles that cannot be sifted through sieve 12, and particles that can be sifted through sieves 12, 18, 30, 60, 90, 100, and 120. Sieve 12 has the largest meshes, and sieve 120 the smallest. The volume of the sample is increased after classification, since particles of the same size are grouped together. Therefore the percentage is used in the final results for comparison. Tables 10 and 11 and text fig. 7 show the characteristic bottom for amphioxus.

The amphioxus lives in sandy ground, which consists of numerous large particles (sieves 12 to 30), and few small particles (sieves 90 to 120). If the condition is reversed, no amphioxus is found. This circumstance may be explained in two ways. Firstly, the mud ground is harder than sand, so the amphioxus cannot burrow in it. Secondly, the fine sand easily interferes with the respiration of the animal, as has been proved in the laboratory.

The sand and mud grounds at Liuwutien are rather distinctly separated. Two scoops of samples were taken about 5 feet apart, one of them containing sand and many amphioxus individuals, while the other contained mud and sponge. Three exceptions, stations 47, 70, and 71, probably very close to the mud ground, were dredged from the very edge of the ground containing sand but no amphioxus.

The number of amphioxus from two scoops of samples (about 1,000 cc) varies with each station, from 6 to 553 individuals. The average is 156.85 individuals and the mode 100 individuals. The number of individuals collected from each station is shown in Table 10 and in text fig. 6, as well as in Table 12.

[1] Made by Flatters and Gurnett Company, England.

TABLE 10.—*Detailed data of bottom samples collected from the amphioxus grounds.*

Station.	Depth.	Number of amphioxus.	Sizes of bottom particles.							
			Cannot be sifted through sieve 12.	Can be sifted through sieves—						
					18	30	60	90	100	120
	m.			*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*
1	4.7	39	165	240	320	450	29	2	1	1
2	4.7	27	185	220	305	260	44	4	1	2
3	2.5	43	120	140	265	530	50	3	1	2
4	3.0	32	150	215	285	470	58	6	1	2
5	2.0	39	50	100	180	510	248	80	11	16
6	2.5	337	30	73	175	700	120	11	3	4
7	3.5	288	175	290	350	370	12	1	1	1
8	7.5	376	80	150	320	520	50	8	2	2
9	4.7	11	40	160	400	460	34	2	1	1
10	7.5	243	110	160	320	520	56	4	1	2
11	4.7	16	210	225	295	410	44	2	1	1
12	10.5	14	1	5	77	950	100	7	1	2
13	9.5	6	1	11	58	950	45	4	2	1
14	6.5	70	45	140	410	520	12	1	1	1
15	4.7	187	200	220	295	420	35	6	1	3
16	6.5	71	100	250	460	310	10	1	1	1
17	6.5	107	75	205	425	405	16	3	1	1
18	4.7	112	175	190	390	370	22	4	2	3
19	9.5	297	60	155	335	530	40	2	2	2
20	7.5	291	60	190	450	400	15	1	1	1
21	7.5	20	15	110	510	460	12	2	1	1
22	6.5	245	260	200	340	275	2	2	4	2
23	9.5	519	400	240	225	275	45	4	2	2
24	13.0	463	125	160	320	475	85	10	3	7
25	9.5	197	65	180	410	410	56	3	1	1
26	7.0	269	60	95	225	670	48	2	1	3
27	8.5	152	200	300	300	255	10	2	1	1
28	6.5	144	35	185	435	420	10	1	1	2
29	5.5	128	130	210	460	310	9	2	1	2
30	9.5	82	220	280	250	395	50	7	3	3
31	8.5	76	75	255	555	195	10	1	1	1
32	14.5	67	45	120	410	480	33	7	2	3
33	7.5	133	175	270	410	240	15	1	1	1
34	11.0	88	105	300	440	270	9	2	1	1
35	9.0	553	55	115	370	550	25	2	1	2
36	8.8	179	30	130	360	545	21	1	1	2
37	9.5	314	5	45	175	735	90	7	2	3
38	10.0	33	15	77	210	725	61	1	1	1
39	9.5	296	5	30	125	800	120	8	2	3
40	10.0	264	110	230	405	330	14	1	1	2
41	9.5	89	30	87	260	550	180	11	1	2
42	11.5	36	20	65	360	560	73	6	1	2
43	14.5	20	55	125	340	550	32	10	2	3
44	13.5	79	300	245	225	405	32	2	2	4
45	16.0	6	60	140	165	110	4	1	1	1
Total	359.3	7,058	4,627	7,533	14,310	20,945	2,078	248	73	108
Average	7.98	156.85	102.82	167	318	465.40	46.20	5.51	1.62	2.40
Percentage	-------	-------	9.29	15.11	28.73	42.05	4.17	0.41	0.15	0.23

TABLE 11.—*Detailed data of bottom samples collected from the vicinity of amphioxus grounds.*[a]

Station.	Depth.	Sizes of bottom particles.							
		Cannot be sifted through sieve 12.	Can be sifted through sieve—						
			12	18	30	60	90	100	120
	m.	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*
46	4.7	250	210	98	300	58	5	4	430
47	2.0	25	40	120	835	77	3	1	2
48	3.0	20	55	125	290	105	18	18	170
49	10.5	140	125	230	90	24	2	2	565
50	8.5	410	165	135	220	195	25	10	20
51	7.5	100	12	63	382	91	8	7	550
52	4.7	300	147	192	177	23	8	8	450
53	12.5	hard ground, no sample							
54	8.0	250	168	158	214	43	6	4	340
55	7.5	260	155	320	105	45	10	3	250
56	10.00	260	155	242	145	80	10	5	355
57	16.5	hard ground, no sample							
58	11.0	100	93	184	185	80	6	6	475
59	12.0	10	69	61	495	80	10	1	400
60	12.3	95	75	48	420	43	6	8	370
61	14.3	80	50	39	452	50	3	2	350
62	13.3	150	262	75	125	28	1	1	400
63	deep	no sample							
64	do	do.							
65	13.0	70	70	58	76	31	9	8	950
66	12.0	160	150	250	151	50	6	5	600
67	9.5	150	127	105	217	70	10	10	550
68	3.5	100	265	127	120	63	12	9	550
69	3.0	200	267	210	133	12	6	4	430
70	3.0	325	340	260	240	17	1	1	1
71	3.5	10	100	450	500	15	2	1	1
72	3.5	180	175	165	183	55	3	5	500
73	2.0	100	210	182	127	23	7	6	550
74	3.5	150	160	120	360	70	20	15	350
Total	198.2	4,125	3,490	4,027	6,042	1,428	197	143	9,809
Average	7.93	165	140	161	242	57	8	6	392
Percentage		14.1	11.9	13.8	20.7	4.9	0.7	0.5	33.5

[a] No amphioxus were found in these samples.

This variation may be explained in three ways: (*a*) the samples dredged by the native scoop are not even, since the construction of the dredging scoop is too simple and the movement of the water varied, especially during the winding time; (*b*) the distribution of the amphioxus themselves is not even, since they can migrate slightly in the ground; (*c*) it depends upon the number of fishing boats at the station—the more the fishing boats the less will be the number of amphioxus individuals per boat.

In June the proportion between the first-year, and the second-year and third-year amphioxus is about 7:10 on the average,

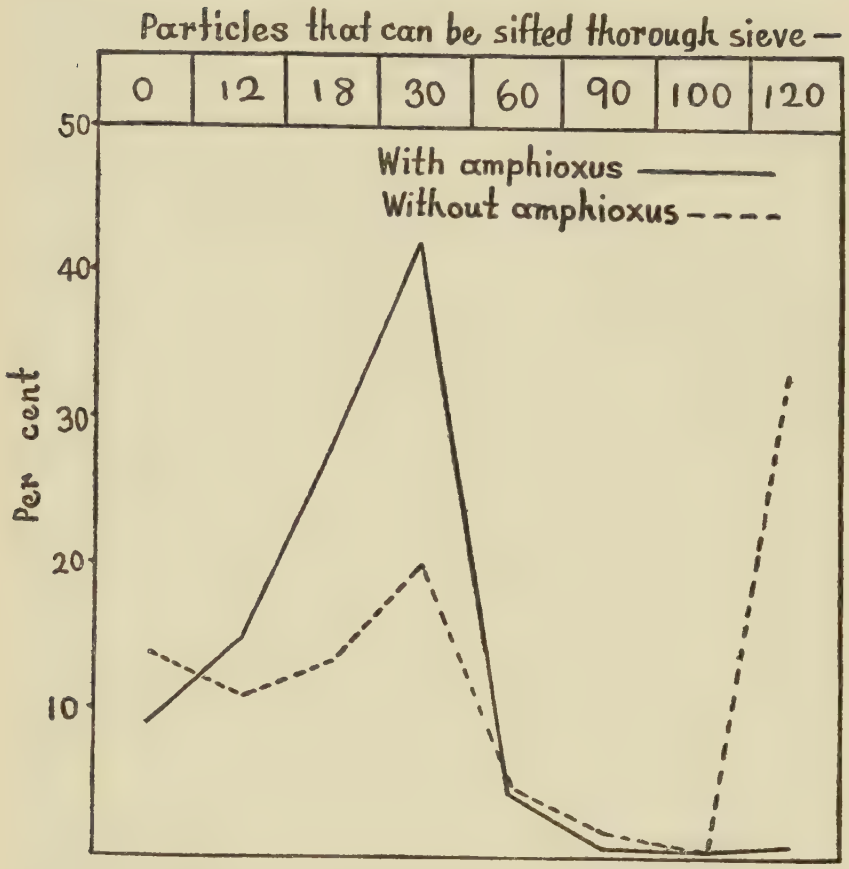

FIG 7. Differences between bottom samples with and without amphioxus, collected from amphioxus grounds and their vicinity. O represents the largest particles of sand that cannot be sifted through sieve 12. 12, 18, 30, 60, 90, 100, and 120 represent particles that can be sifted through the corresponding sieve. 120 is the finest sieve.

TABLE 12.—*Variation in the number of individuals of amphioxus collected from each station.*

Individuals.	Frequency.
1–10	2
11–50	5, 5, 2
51–100	5, 3
101–150	5
151–200	4
201–250	2
251–300	5, 1
301–350	2
351–400	1
401–450	0
451–500	1
501–550	1
551–600	1

but at stations 6, 23, 24, 35, 37, and 39 the individuals are mostly small, since the fishermen usually capture large amphioxus and leave the small individuals.

Depth of the sea.—The amphioxus fishing ground is rather shallow. Sixteen meters was the greatest depth found in this survey, and the amphioxus is also present in the littoral region. The pressure is rather high at a depth of more than 16 meters, but the ordinary air pressure does no harm to the organism. The average sea bottom for amphioxus ground is about 8 meters. The depth of Amoy Sea and its vicinity is shown in text fig. 4, and the detailed data of the ground is given in Table 10. Text fig. 8 shows a section of the sea from Chipbee, and text fig. 9 shows sections of the sea in the amphioxus ground.

Figure 8 is a section of the sea from Chipbee to Liuwutien through Crocodile Island. It shows the presence of amphioxus at different depths and its habitat in general.

Water current in the amphioxus ground.—The amphioxus, especially the younger stage, is not present where a strong current exists. However, a certain amount of current is necessary, since transports food material from the open sea to the feeding grounds. The speed of the water current depends upon the depth of the sea; that is, water currents are stronger in deeper waters. The entrance of the sea water at the North of Amoy Island, from Wu Tung to Au Tau, is shown in text fig. 9, *a*. No amphioxus was found in waters where the bottoms are muddy; as from Wu Tung to Liuwutien and Chung Shih to Liuwutien, shown in text fig. 9, *b* and *c*, which shows a deep groove on the bottom near Amoy Island. The ground with sandy bottom was found to be inhabited by amphioxus. Near the mainland, where the water current was quite slow, the sandy bottom was rather shallow.

The sea between Chung Shih, Chipbee, and Liuwutien is much wider, therefore the current decreases and makes it rather shallow, as shown in text fig. 11.

Text fig. 9, *d*, is a section between Kao Ge and Chipbee. This section, which is quite narrow and shallow, separates the north and south sea waters of Amoy. It is said that several hundred years ago people could walk through this portion during low tide. This narrow neck is quite beneficial to the amphioxus, otherwise fresh water in the southern part of Amoy Sea would get in, dilute the water in the amphioxus ground, and kill the animals.

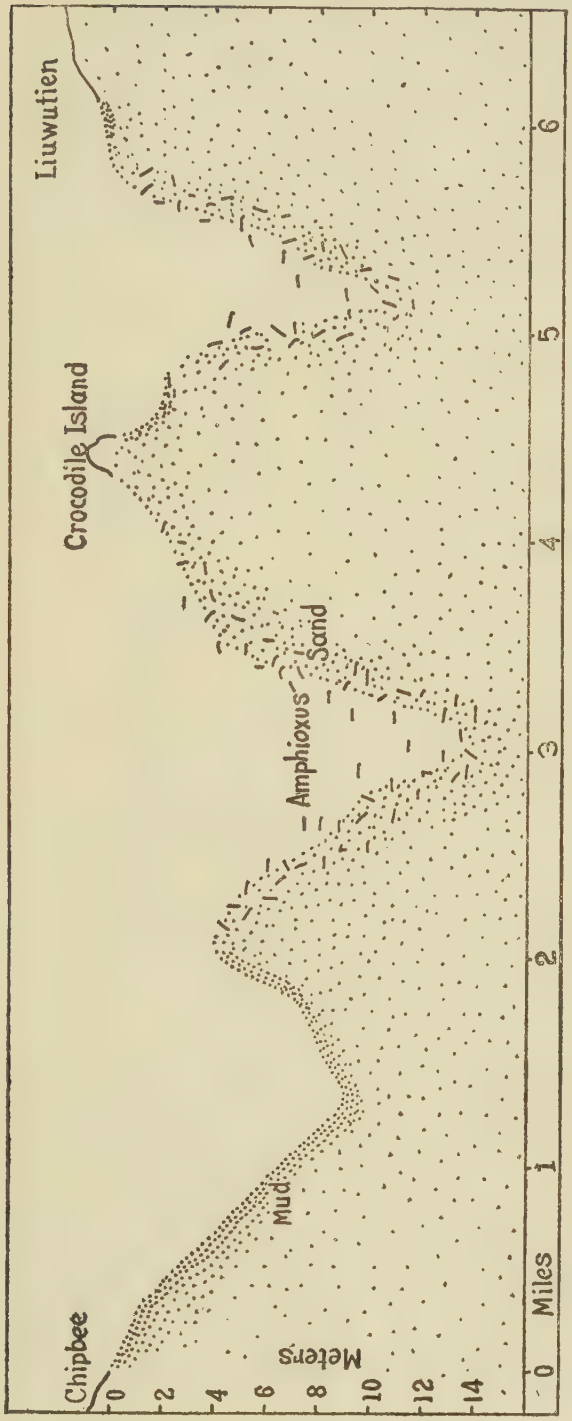

FIG. 8. Section of the sea from Chipbee through Crocodile Island to Liuw utien, showing the nature of the bottom and the distribution of amphioxus.

Specific gravity of the ground sample.—The specific gravity of the sand from the amphioxus ground is comparatively low, since the amphioxus is a sand-burrowing animal. It is not as low as that from the outer shore, where numerous broken calcareous shells are present. In the amphioxus ground there are many broken molluscan shells and other calcareous substances, such as the coral skeleton, echinoderm plates, appendages of crabs, and bones of higher vertebrates. These substances constitute more than 4 per cent of the sample.

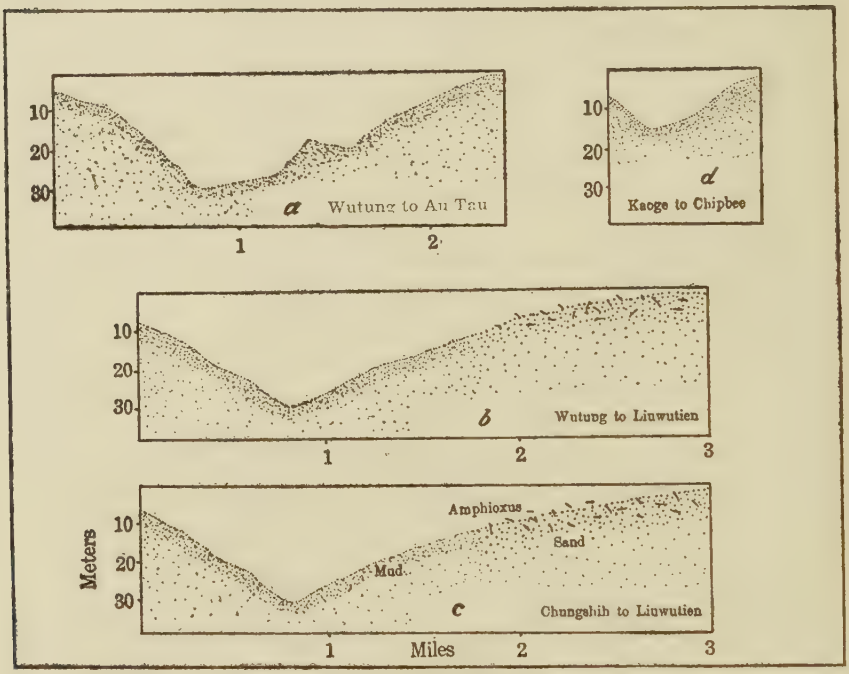

FIG. 9. Sections of the sea in the amphioxus grounds and their vicinity, showing depth and bottom conditions from which the directions of water currents are plotted.

In order to make a comparison on the specific gravity, sand samples were collected from different localities in Amoy and its vicinity, namely: Light House, Chipbee, Nantaiboo, and in front of the University of Amoy. Among them the sand from Light House was the lightest, containing the largest amount of calcareous substances (calculated by carbon dioxide producing power of the sample by adding acid solution), since it was on the margin of the open sea. The Liuwutien sample (amphioxus ground) was next, while the remaining samples contained smaller particles of sand and less calcareous substances, and

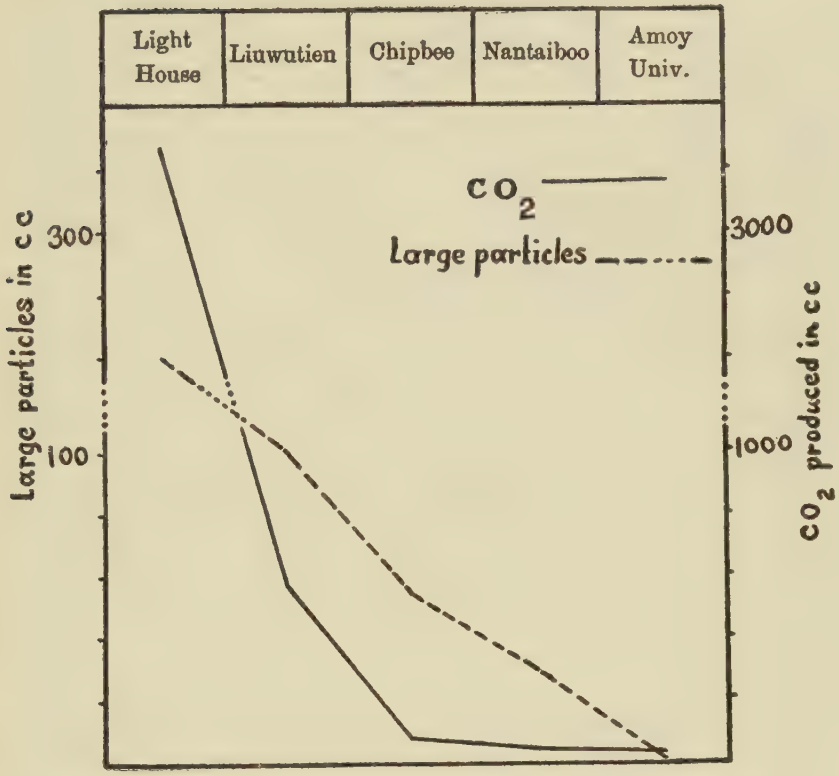

FIG. 10. Correlation between the large particles and carbon dioxide produced.

hence were higher in specific gravity. Table 13 shows a comparative study of sand samples from the amphioxus ground and vicinity. Text fig. 10 shows the correlation between the large particles and the carbon dioxide produced.

TABLE 13.—*A comparative study of sand samples collected from the amphioxus ground and its vicinity.*

Locality.	Volume of different sizes of bottom samples.								Density.	CO_2 produced in 100 cc of sample.
	Cannot be sifted through sieve 12.	Can be sifted through sieve—								
		12	18	30	60	90	100	120		
	cc.	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*	*cc.*
Light house	260	425	350	135	5	2	1	1	1.3330	3250
Liuwutien	102	167	318	465	46	6	2	3	1.3450	592
Chipbee	58	170	570	350	5	2	2	1	1.4040	68
Nantaiboo	28	130	290	656	85	5	2	2	1.3845	20
Front of Amoy University	0	2	10	980	125	9	3	8	1.3955	3

Temperature.—As has been mentioned in the early part of this paper, Amoy is located between the North Temperate and the Subtropical zones. The temperature range in the region is, therefore, not very great. In 1932 the air and water temperatures were taken weekly on the amphioxus ground. The average monthly air temperature reached the lowest level in February, and gradually increased in March and April. From April to May the temperature increased considerably, and reached its highest level in July. Then it dropped down in a smooth curve till the end of the year.

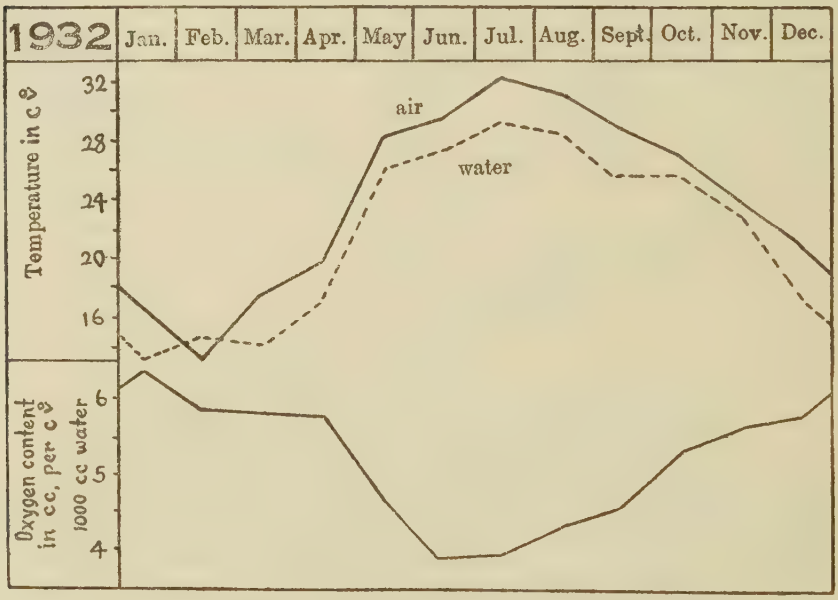

FIG. 11. Temperature and dissolved oxygen content at Liuwutien in 1932.

The lowest temperature recorded during the year was 10.5°C., and the highest, 34°C., for air temperature, and 12.0°C. and 30.5°C., respectively, for water temperature. The average air temperature was 23.5°C. while that for water was only 17.5°C.

The water temperature was always 2 to 3°C. lower than that of the air, except in February when the water temperature was higher. The air and water temperatures recorded showed clearly that the change of temperature in such shallow water was mainly due to air temperature, and was not much influenced either by warm or cold current. Table 14 and text fig. 11 show the temperature range and oxygen content at Liuwutien in 1932.

TABLE 14.—*Temperature and dissolved oxygen at Liuwutien in 1932.*

Data.	January.	February.	March.	April.	May.	June.	July.
Air temperature_____°C.__	16.9	13.3	17.8	19.7	28.3	29.6	32.1
Water temperature_____°C.__	13.7	14.8	14.5	17.3	26.1	27.6	29.2
Oxygen content_ cc per liter__	6.29	5.95	5.93	5.88	4.76	3.92	3.99

Data.	August.	September.	October.	November.	December.	Average.
Air temperature_____°C.__	31.3	29.0	27.0	24.4	21.0	24.2
Water temperature_____°C.__	29.9	25.9	23.2	17.6	17.6	22.1
Oxygen content_____ cc per liter__	4.26	4.59	5.25	5.60	5.82	5.19

Water color, transparency, density, and other data.—The sea water is invariably deep blue and very rarely yellowish. The transparency is from about 0.5 to 2 meters for a white disc with a diameter of 20 centimeters. Since the water is clear, many planktons used as food by amphioxus are present. The density of the sea water is rather higher than in other parts of Amoy Sea, since very little fresh water enters the sea in this region. The density of sea water in relation to its salinity will be discussed later.

The rainfall reaches only the surface water and therefore does not materially influence the living conditions of the amphioxus. The inland rainfall is considerable south of Amoy, but not in the amphioxus ground. The wind at Liuwutien is rather strong, especially during the flood tide in the afternoon. But it does not influence the amphioxus directly, since it only affects the movement of the water.

CHEMICAL CONDITIONS

Salinity.—Different species of animals usually live in different degrees of salinity. If there is only slight change of salinity, the animal will adjust itself, but conspicuous changes may cause its death. If considerable amounts of fresh water enter into the sea from the inland the diluted water may swell the body of amphioxus by osmotic pressure. Amphioxus killed by osmosis assume the shape of a half moon, due to the fact that changes by osmotic pressure take place more rapidly in the gonadal region than in the muscular back. This fact was verified by tests conducted in the laboratory.

The change of salinity depends upon many factors, such as temperature, current, nature of the bottom, fresh water, and

others. But the change in this region is influenced mainly by the fresh water from inland, especially during the rainy season. The higher the volume of rainfall, the lower the salinity will be. Table 15 and text fig. 12 show the salinity, rainfall, and pH value at Liuwutien and Kulangsu in 1932.

TABLE 15.—*Salinity, rainfall, and pH value at Liuwutien and Kulangsu in 1932.*

Data.	January.	February.	March.	April.	May.	June.	July.
Liuwutien, salinity per 1,000 cc.	27.2	28.2	27.4	26.7	26.1	24.3	28.5
Kulangsu, salinity per 1,000 cc.	26.2	25.7	22.1	22.8	25.6	13.4	27.1
Amoy Island, rainfall mm.	0	31	113	192	145	226	155
Liuwutien, pH value	8.40	8.40	8.36	8.40	8.36	8.40	8.40
Kulangsu, pH value	8.40	8.33	8.32	8.30	8.35	8.36	8.40

Data.	August.	September.	October.	November.	December.	Average.
Liuwutien, salinity per 1,000 cc.	27.7	25.7	27.8	28.3	27.7	27.1
Kulangsu, salinity per 1,000 cc.	26.8	20.0	26.2	24.3	25.5	23.8
Amoy Island, rainfall mm.	174	123	0	18	45	101.9
Liuwutien, pH value	8.40	8.36	8.40	8.35	8.40	8.39
Kulangsu, pH value	8.32	8.30	8.40	8.30	8.40	8.35

A sample of 10 cc sea water was taken and titrated with the usual solution of silver nitrate used in this determination, and then calculated into salinity per 1,000 cc of water. The average salinity at Liuwutien was 29.1 grams per liter, highest in July (30.5 grams per liter), and lowest in June (26.3 grams per liter). The highest for each collection was 31.8 grams per liter, at the end of July, and the lowest, 24.4 grams per liter, at the beginning of June. The range was only 7.4 grams per liter.

This condition is quite different on the south side of Amoy Sea, which is the outlet of a large river. At the beginning of June the sea was nearly filled with fresh water, containing only 5.2 grams per liter salts. At the end of July the salinity reached 31.7 grams per liter. The difference is 26.5 grams per liter. Such great changes killed many sea animals during the rainy season. It is quite fortunate that the sea water of the south and the north is not easily mixed, on account of the different current systems, the presence of the shallow and narrow strait between Kao Ge and Chipbee, and the production of the main fresh current near the south end of South Amoy Sea where a deep groove is present.

Hydrogen-ion concentration.—The hydrogen-ion concentration of sea water affects the respiration and other physiological conditions of the animal. It is, therefore, important in the ecological study of amphioxus.

For the pH value, colorometric determination by a comparator block was used. To 10 cc sea water is added 0.5 cc 0.2 per cent cresol red, and the sea water is then compared with the standard color disc against light. Sixty-four samples were tested, all except 5 having a value of 8.4. The exceptional 5 were a little higher (8.6) and lower (8.2). In the

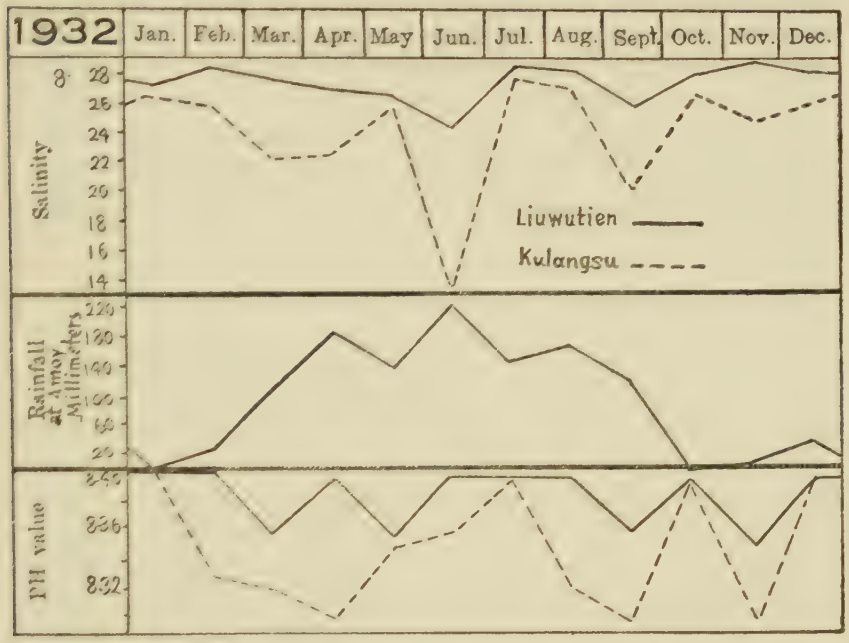

FIG. 12. Salinity and pH value at Liuwutien and Kulangsu; and rainful at Amoy in 1932.

southern part (Table 15 and text fig. 12) the pH value was usually very low, due to the fresh water from inland and organic matter from Amoy City.

The pH value of the bottom samples was also tested. One cc sand or mud was added to 12 cc of water, and the water shaken thoroughly and allowed to stand till clear. Ten cc of the superficial water were then poured into the test tube and tested as above. The sand sample had a pH value of 8.4, like the sea water itself, while the mud sample gave a much higher acid value, 7.2. This factor probably helps to explain why amphioxus cannot live in muddy ground.

Dissolved oxygen.—The dissolved-oxygen content is essential for the respiration of the animals. Its fluctuation depends mainly upon the temperature of the water. At low temperature the water contains more oxygen, and at high temperature it contains less oxygen. Winkler's method was used in the oxygen determinations. The lowest record was 3.92 cc per 1,000 cc water in June and 6.29 cc per 1,000 cc in January, the latter being the highest in average. The yearly average was 5.19 cc in 1932.

Other chemical conditions.—The detailed analysis of the sea water from the amphioxus ground was worked out by Liu and Shé.(27) The data of these workers were based upon three collections in the fall and winter of 1932, and spring of 1933.

Most of the elements or compounds mentioned in this paper are not directly related to amphioxus, but they are related to the chemical composition of the sea water and growth of food materials. For this reason the results of the analysis are given in Table 16.

TABLE 16.—*Chemical analysis of sea water from amphioxus grounds.*

Substance.	Fall.	Winter.	Spring.
	p. p. m.	*p. p. m.*	*p. p. m.*
Nitrate	0.2440	0.8060	0.5230
Nitrite	0.1310	0.4270	0.2300
Phosphorus pentoxide	0.0020	0.0040	0.0034
Sulfate	2290.0000	2230.0000	2150.0000
Carbonate	8.4000	9.0000	8.9000
Bicarbonate	98.2000	97.6000	99.4000
Chloride	14705.000	16,906.0000	16,706.0000
Bromide	55.8000	56.0000	56.8000
Iodine			0.0190
Saline ammonia	7.0400	8.2600	7.5300
Albuminoid ammonia	38.3000	40.8000	41.4000
Silica	2.0000	2.5000	1.5000
Potassium	365.0000	359.0000	328.0000
Sodium	10,140.0000	9,940.0000	10,620.0000
Calcium	323.0000	342.0000	320.0000
Magnesium	1,152.0000	1,166.0000	1,126.0000
Iron	0.2000	0.0200	0.0400

Among the above elements or compounds, nitrate, nitrite, phosphorus pentoxide, and silica affect the growth of diatoms. Carbonate and bicarbonate affect pH value. Cloride, bromide, iodine, potassium, sodium, calcium, magnesium, and iron affect salinity. Saline ammonia and albuminoid ammonia affect bacteria in the water.

BIOLOGICAL CONDITIONS

Animals and plants used as food by amphioxus.—Microscopic plankton in the sea water, small protozoa, small plants, and decomposed material at the bottom constitute the chief food of amphioxus. The commonest among them are the diatoms.

More than 200 young (less than 8 mm long) amphioxus were examined, and only small diatoms were found in their digestive tracts. The commonest species were *Paralia sculata, Coscinodiscus lineatus, Nitzchia* spp., *Navicula* spp., and *Rhizosolenia* spp. More than 200 large (45 to 50 mm long) amphioxus were examined by squeezing the fæcal matter out from the intestines and treating the latter with acid. The diatoms observed were *Podosira stelliger, Actinocyclus Ehrenbergi, Coscinodiscus lineatus, C. excentricus, C. subtilis, C. marginatus, C. asteromphalus, Cyclotella striata, C. stylorum, C. comta, Actinoptychus undulatus, A. annulata, Triceratium favus, T. Broeckii, Biddulphia pulchella, Trachyneis aspera, T. clepsydra, Navicula crabro, N. elliptica, N. lyra, N. longa, N. directa, N. abrupta, Amphora commutata, Pleurosigma Normanii, P. pelagicum, P. naviculaceum, Surirella fluminensis, Campylodiscus* (?) *cocconeiformis,* and *Nitzschia punctata.*(8)

The following planktonic organisms were commonly collected from the sea water of the amphioxus ground. All of them were easily dissolved by hot acid. Some of them were dissected from the pharynx or intestines of living amphioxus. The forms collected were *Corethron criophillium, Chaetoceras decipiens, Biddulphia sinensis, Asterionella formosa, Leptocylindrus denicus, Coscinodiscus lineatus, Thallassiothrix nitzschioides, Guinardia* sp., *Eucampia zodiacus, Rhizosolenia shrubsolei, Noctiluca scintillans,* tunicate larvæ, echinoderm larvæ, crustacean larvæ, and copepod larvæ.

Animals that seem to be indifferent to amphioxus.—Three groups of animals were found in the amphioxus grounds, namely: molluscan shells, annelids, and crabs. Some of them are beneficial and others harmful, but most of them are apparently indifferent to amphioxus.

Molluscan shells:

Murex martinianus Reeve, few; *Ranella tuberculata* Bred., few; *Surcula tuberculata* Gray, rare; *Engrina sinensis* Melville, rare; *Natica fortunei* Reeve, rare; *N. maculosa* Lamarck, few; *Pyramidella elegans* (Adams), few; *Scalaria obesa* Sowerby,

rare; *S. acuminata* Sowerby, rare; *Potamides fluviatilis* (Potiz and Michaud), few; *Triforis fusca* Dunker, rare; *Euchelus horridus* (Philippi), common; *Retusa cecillei* (Philippi), common; *Cuma grada* (Jonas), abundant; *Eburna lutosa* Lamarck, few; *Erillia lanceolata* (Reeve), rare; *Turritella bacillum* Kien, common; *Turbonilla terebra* Dunker, few; *Scalaria aculeata* Sowerby, few; *Cerithium rubus* (Martin), few; *Minolia stigata* Sowerby, common; *Columbella dunkeri* Tryon, few.

All the above specimens were dredged at Liuwutien during the study of the distribution of amphioxus. With the presence of these shells and other calcareous materials the amphioxus ground is always kept at a pH value 8.4, which is the optimum condition for the amphioxus.

Annelids:

Table 17 shows the annelids found in the amphioxus ground.

TABLE 17.—*Annelids found in the amphioxus ground.*

Name.	Specimens collected.	Time of collection.
Clymens (*Euclymens*) *insecta* Ehlers	few	June.
Diopatra dentata Kinberg	do.	Mar.–June.
Eunice gracilis Crossland	rare	June.
Glycera chirori Izuka	few	Jan.–April.
Glycera onomichinensis Izuka	abundant	Whole year.
Blycinde sp. (juvenile)	do.	Do.
Lunbricinereis ocellata Grube	do.	Do.
Lysidice collaris Grube	few	Winter spring.
Marphysa sanguinea Montagu	do.	June–July.
Nephthya sinensis Fauvel	abundant	Whole year.
Nereis sp. (juvenile)	rare	June.
Onuphis eremita Aud. & Edw.	do.	June–July.
Phyllodoce malmgreni Gravier var.	do.	June.
Polydora ciliata Johnston	abundant	Whole year.

All annelids mentioned in Table 17 (8) are indifferent to amphioxus, and they are less numerous than amphioxus.

Crabs collected by previous workers in the University of Amoy, and identified by Dr. M. J. Rathbun(39) of the United States National Museum:

Camptandrium elongatum Rathbun, *Eucrate crenata* de Man, *Ilyoplax delsmaniyuhana* Rathbun, *I. cerarophora* (Loelbel), *I. orientalis* (de Man), *Charybdis mergniensis* (de Man), *Metaplax elegans* de Man, *Sor fukiensis* Rathbun, *Uca forcipata* (Adams & White), *Parapanope euagora* de Man, *Sesarma* (*Parasesarma*) *batavianum* de Man.

Enemies of amphioxus.—Starfishes feed upon amphioxus, but they are relatively scarce at Liuwutien. Fishes also feed upon amphioxus, especially the larvæ. Many kinds of infusoria, such as *Oxytrica ferruginea* Stein, *Euplotes harpa* Stein, and others, in the amphioxus grounds, are also harmful to amphioxus. Ciliates easily kill amphioxus by infecting them through injured parts, however small the wounds may be.

The tide is also harmful to amphioxus during the breeding season, since it carries away young amphioxus to unsuitable places.

As a whole, the so-called unfavorable conditions found in Amoy waters are not sufficient to cause the depletion of amphioxus.

Fisheries.—Man catches amphioxus for food. However, since the amphioxus on the ground are quite numerous, and people usually do not fish amphioxus during the breeding season, the amphioxus fishery is well protected from depletion.

HOW TO KEEP AMPHIOXUS ALIVE IN THE LABORATORY

The above studies clearly determined the optimum environment of amphioxus, and with the information obtained I was able to keep amphioxus alive in the laboratory. They were kept in good health in the laboratory for 8 months, and died only after I left Amoy. Square (6- by 6- by 10-inch) museum jars were used for holding five to ten individuals. Essentially each jar contained clear sea water and a sandy bottom about 0.5 inch thick. Favorable conditions essential to the life of amphioxus include the following:

Health.—The regenerating power of the amphioxus is very low. An injury of the skin does not heal readily, so that the wounded portion is infected by many kinds of infusoria and bacteria, which multiply rapidly and finally kill the amphioxus. Therefore care must be observed in washing the amphioxus. If some wounded amphioxus are found they must be removed immediately. Examination for wounded individuals must be made every 12 hours during the first few days.

Hydrogen-ion concentration (pH value).—A certain range of pH value is necessary for the life of amphioxus, which can be maintained in good condition in waters between pH 7.4 and 8.6. If acidity increases to 7.2 or more the amphioxus die within a few minutes, and if alkalinity increases to 8.8 or more they also die quickly, since the water has lost its buffer reaction.

Temperature.—From the above studies we know that the optimum range of temperature for amphioxus is from 12 to 30.5° C. Within this range it is not difficult to keep them alive. But the two extreme temperatures are not suitable. The most favorable period to keep the amphioxus in the laboratory is in the spring and fall, but it is possible to keep them alive in the cold winter and in the hot summer by increasing or decreasing the temperature by artificial means, as the case may be.

Water.—Large quantities of water are necessary to keep all the physical, chemical, and biological conditions as constant as possible. All museum jars must be covered partly to cut down the evaporation of the water and to protect it from the dust in the air.

Salinity.—The most important factor relative to amphioxus in the laboratory is the amount of salinity. The changes of salinity at Liuwutien are relatively small, only 7.4 grams per liter difference during 1932. An experiment was carried out in the laboratory to test the amount of salinity required by amphioxus. The pH value of the water used was 8.4. The results are shown in Table 18.

TABLE 18.—*Amphioxus in relation to salinity.*

Salt content in 1,000 cc water.	Length of life.	Salt content in 1,000 cc water.	Length of life.
		cc.	
0.2	2 seconds	24.2	Nil.
3.0	do	29.2	Do.
5.0	1 minute	32.6	3 days.
7.5	2.5 minutes	35.5	1.5 days.
9.5	3.0 minutes	38.5	1.0 day.
11.6	3.5 minutes	41.5	3 minutes.
14.0	4.0 minutes	50.0	2 minutes.
16.2	5 days	65.0	10 seconds.
19.2	Nil	80.0	2 seconds.

Table 18 shows that between 19.2 and 29 grams of salt per liter, amphioxus can live normally. Salinity contents beyond either extreme kills the animals. The experiment has been repeated 6 times with similar results.

Food.—Amphioxus may be kept in the laboratory without food for from 1 to 2 months, but they do not grow and usually lose weight. If some microplankton is added to the water from

time to time, they grow normally. Among planktons diatoms are the best food.

Summary.—In order to keep amphioxus alive in the laboratory the animals must not be injured; the pH of the water should be about 8.4; the temperature must be between 12 and 30°C.; and the salinity must be from 19 to 29 grams per liter. Moreover, the quantity of water must be kept more or less constant, and the food should consist of microplankton, among which diatoms are best. Given these conditions, amphioxus can be kept in the laboratory without much trouble.

VERTICAL DISTRIBUTION OF YOUNG AMPHIOXUS

Young amphioxus are found in the plankton population by some zoologists, such as Bles(2) at Plymouth. In the summer of 1933, while I was engaged in the collection of embryological stages of amphioxus, I had opportunity to study the vertical distribution of young amphioxus. Adult amphioxus usually burrow in the sand and rarely swim in the water, but larvæ from 2 to 3 millimeters long invariably swim about and form part of the planktonic fauna of the sea.

METHODS

The plankton net used was made of raw silk, with 913 meshes per square centimeter, with a tin funnel at its tip. Two nets were used in towing, one placed near the surface and the other at the bottom of the water. The area of each net was 1,661.91 square centimeters. The net was attached to a small boat with a constant speed, traveling 1,600 meters in half an hour in all collections, so that the total volume of sea water filtered in each collection was nearly 266 liters. Concentrated formalin (with borax) was added to the water to make a 5 per cent solution. In this way the specimens are both fixed and preserved.

The oxygen content was determined according to Winkle's method, the pH value was compared with a colored disc against light by adding cresol red indicator, and the total salt concentration was calculated by the volume of silver nitrate solution used in the presence of potassium chromate indicator. The height of the tide was calculated from the tide table at Amoy and not from actual measurements. Table 19 and text fig. 13 show the physical conditions of the amphioxus ground at Liuwutien, Amoy, and the distribution of amphioxus, July 8 and 9.

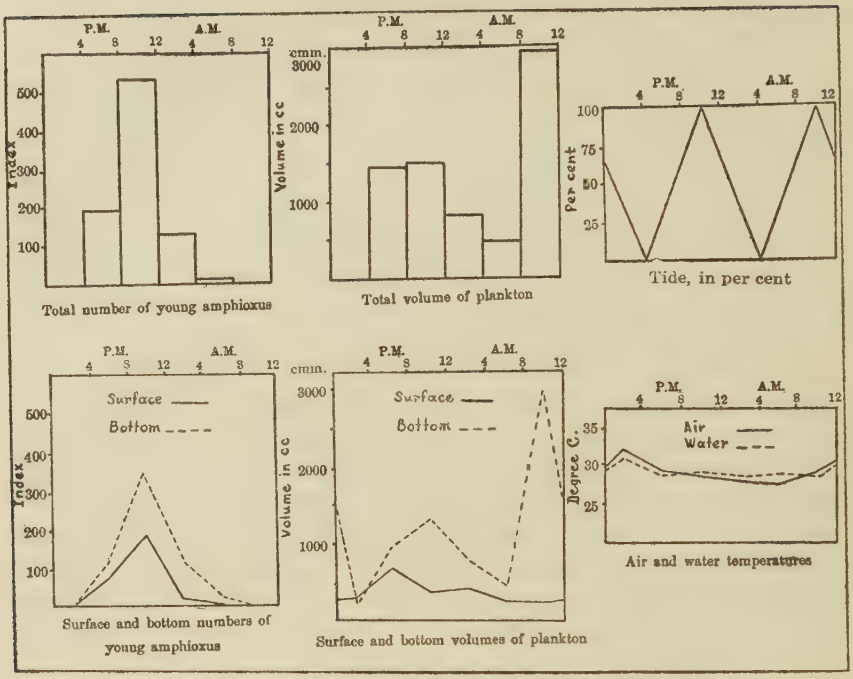

FIG. 13. Vertical distribution of young amphioxus and other related phenomena.

TABLE 19.—*Distribution of young planktonic amphioxus and its relation to other phenomena.*

Weather: sunny, blue sky, no wind, no clouds; locality: Liuwutien, Amoy, 24° 35′ north latitude, 118° 11′ east longitude; date: July 8 and 9, 1933; oxygen content: 3.9 cc in 1,000 cc water; pH value: 8.4; salinity: 27.2 grams in 1,000 cc water.

Date.	Time.	Tide mark.	Light intensity.	Temperature.	
				Air.	Water.
		Per cent.	*Per cent.*	°*C.*	°*C.*
July 8	2 P. M.	33.4	100	32.2	31.0
	6 P. M.	33.4	50	29.0	28.8
	10 P. M.	100.0	0	28.0	28.8
July 9	2 A. M.	33.4	0	27.7	28.9
	6 A. M.	33.4	50	27.2	29.0
	10 A. M.	100.0	100	29.0	28.9

Date.		Plankton volume.			Young amphioxus.		
		Surface.	Bottom.	Total.	Surface.	Bottom.	Total.
		cc.	*cc.*	*cc.*			
July 8	2 P. M.	228	212	440	0	0	0
	6 P. M.	707	990	1,697	73	120	193
	10 P. M.	389	1,343	1,732	186	360	536
July 9	2 A. M.	410	778	1,088	18	115	133
	6 A. M.	283	424	707	0	4	4
	10 A. M.	212	2,969	3,181	0	0	0

DISCUSSION

The floating organisms or plankton in the sea drift with tide and current. Thus distribution depends partly on physical and chemical changes of the sea water, particularly in the case of planktonic amphioxus.

Change in oxygen content may affect the distribution of plankton and other living organisms, but since the oxygen content at Liuwutien is nearly saturated the distribution depends upon the temperature only. Since the temperature is nearly uniform throughout the day, it is not necessary to determine it in all collections. Changes in pH value and salinity are mainly due to the influx of fresh water either from inland or from rains. This finding was confirmed by observations made during the year.

Table 19 and text fig. 13 show many correlations in positive and negative directions. The number of young amphioxus collected shows inverse correlation with the intensity of sunlight. When sunlight was strong, young amphioxus had the tendency to burrow in the sand, and when the light became less bright they became more active and swam in the sea. After 10 P. M., when the intensity of light became weaker and the sea water darker, young amphioxus could be collected from both surface and bottom nets. At midnight the number of young amphioxus collected was at its height, decreasing gradually thereafter until no more amphioxus could be collected with the surface net and only 4 specimens with the bottom net. All these findings show that amphioxus is negatively phototropic, confirming the results of Parker's experiments.(37)

Aside from the effects of light intensity, the distribution of amphioxus and the frequency curve of the number of young amphioxus collected is governed also by the tide, which carries the water in between 4 and 10 P. M., bringing with it the young amphioxus from the eastern part of the amphioxus grounds. After the highest tide mark is reached, the young amphioxus are again carried away with the tide, so that the number of amphioxus at 6 A. M. is less than that at 6 P. M. Thus the frequency curve is not symmetrical.

The distribution of young amphioxus is influenced by the tide but not correlated with it. If it were, there ought to be a large number of young amphioxus at 10 A. M., when the tide is supposed to have reached the highest level and the volume of the total plankton collected in the net is largest. However,

this was not the case, as the tide was found not to correlate with the distribution of young amphioxus.

The height of the tide and the total volume of the plankton showed a positive correlation. Both maximal and minimal points were apparently the same. When the tide comes, it usually brings in living floating organisms, and when it goes out, it carries them away. The total volume of each sample from the surface tow net was almost the same from each collection, but it was quite different among bottom samples. The total volume from the bottom net in each collection changed greatly during the day. From this observation we may conclude that the changes of sea water were limited only at the bottom and the planktonic organisms were likewise limited at that particular space and time. From this study it appears that the asymmetrical distribution of the number of young amphioxus as well as plankton is influenced by the tide. If the water decreases rapidly at midnight a large number of young amphioxus may be carried away from the grounds. Although the second tide of the day may carry some of them back again, it always occurs at noon when the young amphioxus confine themselves to the bottom.

GROWTH OF AMOY AMPHIOXUS

Considerable difficulty was encountered in the study of the growth of amphioxus, since they live at the bottom of the sea and no observation would be made directly. It was also difficult to maintain the natural conditions for the study of their growth in the laboratory. The present report deals with a statistical study of the sizes of amphioxus from which was computed the rate of growth of amphioxus.

Methods.—Sixty-three collections were made during 1931 and 1932. Ten monthly samples were obtained (except during July and August) in 1931, and the remaining 53 samples were collected at weekly intervals in 1932.

Collections of samples were made throughout the whole experiment in grounds between the town of Liuwutien and the Crocodile Islands. The collector and the fisherman who made the collections were maintained throughout the experiment. Each sample usually consisted of 5,000 cc of sand. It was taken in a tin bucket, and contained several hundreds of amphioxus. Separation by washing the sand from the amphioxus was done in the laboratory, care being taken to search for small indivi-

duals. After washing the amphioxus were carefully placed in large dishes with adequate clear sea water. Then they were narcotized with magnesium sulphate. Several drops of 10 per cent formalin solution was added subsequently in order to kill the amphioxus. The dead individuals were then moved to another dish containing 10 per cent formalin for preservation. In this way the amphioxus were easily fixed and preserved.

The individuals were classified into different groups according to that age, for the purpose of making a statistical study by the method used by Galton for separating the 19 kinds of beans in a mixed condition. The writer classified them into four age groups, namely: (1) The first-year amphioxus; that is, from the young presumably hatched in June and July to the end of the year, during a period of 6 months. (2) The second-year amphioxus; that is, those hatched in June and July of the preceding year. These amphioxus were from an age group of 6 months old to 1.5 years old. (3) The third-year amphioxus; those hatched in the year before the last, from 1.5 to 2.5 years old. (4) The fourth-year amphioxus; those from 2.5 to 3 years old. The amphioxus may die after attaining this age.

Second-year and third-year amphioxus may be divided into subclasses, such as (*a*) those without gonads, (*b*) those with little gonads, (*c*) those with large gonads, and (*d*) those with spent gonads.

After the classifying work was finished the amphioxus were bottled and carefully labeled. All the specimens were deposited in the Department of Biology, the National University of Amoy, Amoy.

Measurements of the individuals were made with a short meter stick in a small petri dish in a wet condition. One hundred thousand amphioxus were studied and measured for this work. About one out of ten individuals were collected in 1931, and the rest in 1932. The gonads were measured under a Greenough binocular microscope with the aid of an ocular micrometer. The lengths of the amphioxus represented the average lengths of the class. Dates of collection and other data for 1932 have been discussed in the section on ecology. Table 20 and text figs. 14 and 15 show the rate of growth of amphioxus, in 1931 and 1932; Table 21 shows the actual number of individuals collected in 1932, and Table 22 shows the number for each class in percentage. Text fig. 16 shows the growth of gonads in second-year and third-year amphioxus, and text fig.

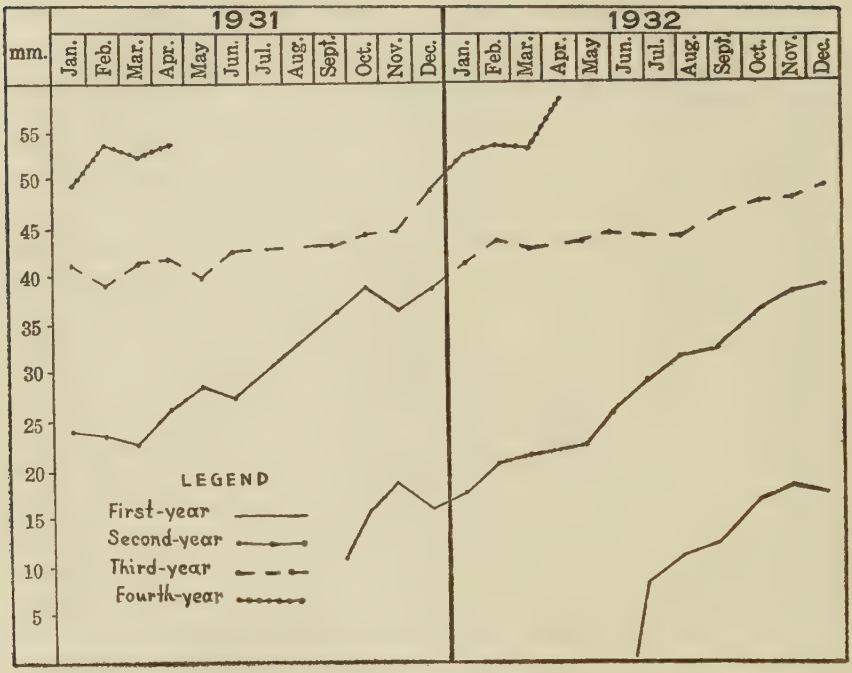

FIG. 14. Growth of amphioxus in 1931 and 1932.

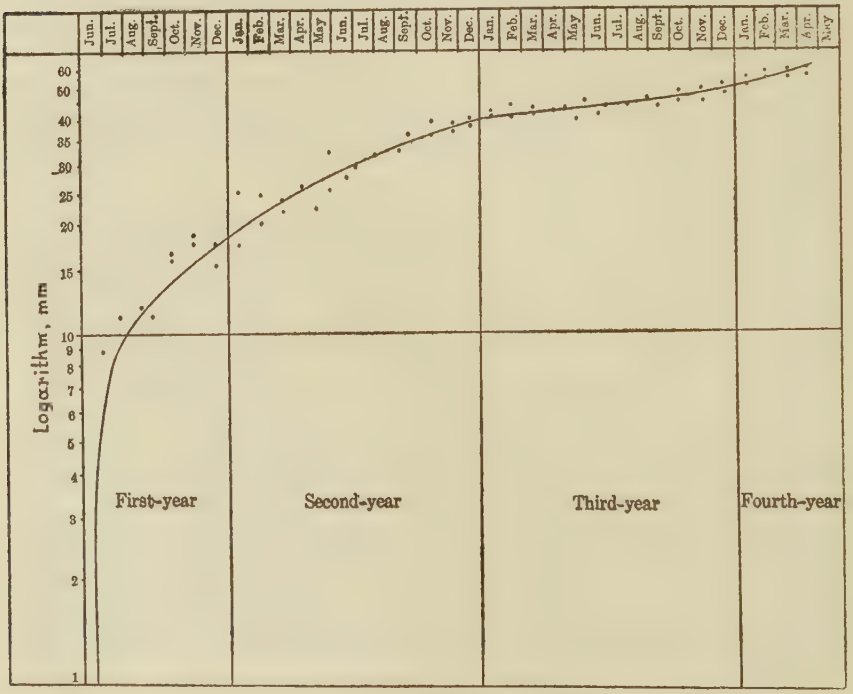

FIG. 15. Rate of growth of Amoy amphioxus, expressed in logarithmic curve.

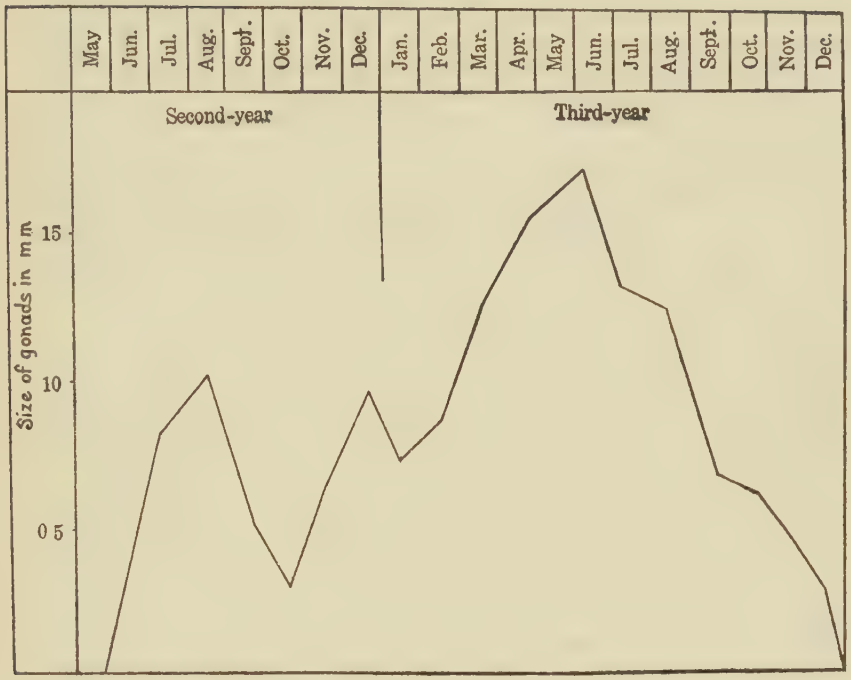

FIG. 16. Growth of gonads in second-year and third-year amphioxus.

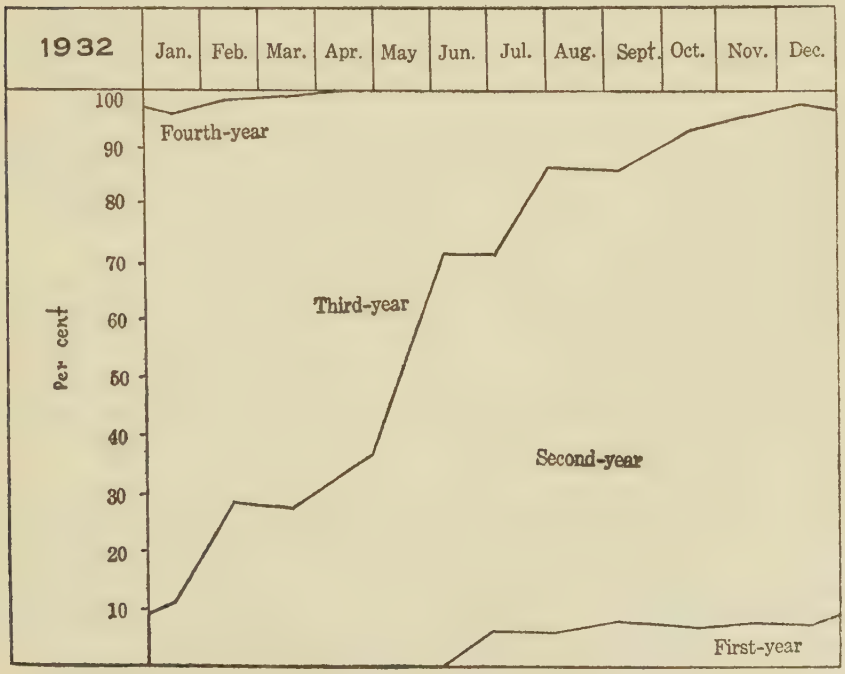

FIG. 17. Different aged amphioxus in each month, in per cent.

17 shows the ages by percentage of amphioxus caught in each month.

TABLE 20.—*The growth of amphioxus, in millimeters.*

Date of measurement.	Amphioxus.						Gonads.	
	Less than 6 months old.	1st-year.	2d-year.	3d-year.	4th-year.	Smallest.	2d-year amphioxus.	3d-year amphioxus.
1931								
January			24.64	41.32	49.36			
February			24.00	39.93	53.20			
March			22.95	41.58	52.10			
April			26.12	41.75	53.00			
May			28.42	40.01				
June			27.49	42.55				
July–August								
September		11.11	36.09	43.38				
October		16.13	38.91	44.59				
November		18.75	36.38	44.59				
December		15.63	38.75	48.18				
1932								
January 1 to 31		17.74	41.14	52.10		8.2		0.726
February 1 to March 9		20.20	43.48	53.20		8.0		0.861
March 10 to 20		21.31	42.81	52.86		10.0		1.258
March 31 to May 18		22.06	43.61	57.00		10.0		1.588
May 19 to June 13		25.19	44.87			12.0		1.711
June 14 to July 13	8.80	29.12	44.30			3.0	0.806	1.322
July 14 to August 21	11.00	31.19	44.15			7.0	1.022	1.242
August 22 to September 30	11.70	32.10	45.61			7.0	0.504	0.684
October 1 to 31	6.71	36.11	47.27			6.0	0.278	0.604
November 1 to 30	18.07	37.78	47.49			11.0	0.662	0.794
December 1 to 31	17.54	38.40	49.20			8.0	0.950	1.260
	1st-year	2d-year	3rd-year	4th-year				

Breeding season.—The breeding season of amphioxus, as shown by the number of newly-hatched amphioxus obtained and by the size of the gonads measured, occurs twice a year; (*a*) from May to July, and (*b*) in December.

The size of the smallest individuals is given in Table 20, showing that the smallest of the small amphioxus collected monthly were collected in the middle of June, after which the individuals increased in size until the end of November. In December the smallest size of amphioxus (8 mm long) appeared again, another group of young amphioxus having been spawned at that time.

The determination of the breeding season on the basis of the finding of the smallest amphioxus is not a very accurate method, since the tiny individuals may be easily lost during washing. Therefore the size of gonads was also measured. The results appear to indicate more definitely the breeding season.

TABLE 21.—*Actual number of amphioxus of each class collected.*

1932	1st-year.	2d-year.				3d-year.			4th-year.
		Small.	Without gonads.	With small gonads.	With large gonads.	Without gonads.	With small gonads.	With large gonads.	
January 1 to 31		488				1,036	1,120	1,319	180
February 10 to March 9		1,329				637	1,174	1,546	76
March 10 to 30		1,134				716	919	1,235	39
March 31 to May 18		2,288				767	956	2,167	1
May 19 to June 13		3,804		339			317	1,258	
June 14 to July 13	893	5,122		5,151	2,193		119	3,635	
July 14 to August 21	902	5,942		2,469	2,299		425	1,105	
August 22 to September 30	1,139		7,746	3,052	304	46	1,542	175	
October 1 to 31	478		4,555	1,234		126	334		
November 1 to 30	471		3,703	1,646	8	50	214	2	
December 1 to 31	696		3,600	3,018	506		193	25	
Total	4,579	20,130	19,604	13,309	5,310	3,155	7,313	12,517	296

TABLE 22.—*Amphioxus of each class collected, in percentage.*

1932.	1st-year.	2d-year.				3d-year amphioxus.			4th-year.
		Small.	Without gonads.	With small gonads.	With large gonads.	Without gonads.	With small gonads.	With large gonads.	
January 1 to 31		10.9				25.2	27.3	32.2	4.4
February 1 to March 9		28.9				13.2	24.3	32.0	1.6
March 10 to 30		28.1				17.7	22.7	30.5	1.0
March 31 to May 18		37.0				12.3	15.5	35.1	0.1
May 19 to June 13		65.8		5.9			5.5	21.8	
June 14 to July 13	6.6	37.8		11.4	16.1		0.9	27.2	
July 14 to August 21	6.2	45.4		18.9	17.6		3.3	8.6	
August 22 to September 30	8.1		55.3	21.8	2.2	0.3	11.0	1.3	
October 1 to 31	7.1		67.7	18.3		1.9	5.0		
November 1 to 30	7.8		61.0	27.0	0.08	0.8	3.5	0.03	
December 1 to 31	8.7		44.9	37.7	6.0		2.4	0.3	

The first-year amphioxus had no gonads. But the second-year individuals had little gonads at the end of May which enlarged quickly in June and reached their maximum size in July. After July many amphioxus were spawned, and as a result the average size of the gonads decreased. Beginning with December the gonads became enlarged again, and decreased again in January of the following year. The degree of shrinkage in this period was very slight, since only a few amphioxus were spawned in December and January.

The gonads of the third-year amphioxus became larger and larger and reached their maximum size in May. Then they decreased gradually and reached their minimum in December. During this decreasing process numerous amphioxus were born. The fourth-year amphioxus was the largest but contained no gonads; at about that age the animal presumably dies.

From the study of the size of gonads we may infer that the amphioxus had three spawning seasons during the period under study. The first was in June and July, 1931, when the amphioxus was 1 year old. In this period a moderate number of amphioxus were born. The second spawning period occurred in December and January, when the amphioxus was 1.5 years old, and in this period relatively few amphioxus were born. The third occurred from May to December, when the amphioxus was 2 to 2.5 years old, and in this period numerous amphioxus were born.

The growth of amphioxus.—The growth data is shown in Table 20 and text fig. 14. All measurements in the table represent averages of numerous individuals (Table 21) collected.

First-year amphioxus.—In June, 1932, several hundreds of small amphioxus, measuring around 8.8 mm, were collected. These grew to a length of 17.54 mm by the end of the year, increasing their size by 8.74 mm between June and December. More or less the same rate of growth obtained for the first-year amphioxus of 1931.

Fortunately I also collected many very young amphioxus by tow net in July, 1933, as mentioned in connection with the vertical distribution of the young amphioxus.

The specimens collected were from the 1-gill stage to the 12-gill stage, and had a length of about 6 mm. Thus the amphioxus grew fastest during the first few weeks and reached a length of 8.8 mm. Therefore the rate of growth (text fig. 15) was highest in the first few weeks and slowed down before the end of the first half year.

Amphioxus collected in December were smaller than those collected in November, both in 1931 and in 1932, apparently due to the appearance of newly-hatched amphioxus in this period. There was no way of separating the new individuals from the older ones, since the breeding season for the third year amphioxus was continuous from May to the end of the year as mentioned before. Moreover the young individuals, born from the second-year and the third-year amphioxus were similar and could not be distinguished from one another.

Second-year amphioxus.—The second-year amphioxus in 1932 were born in June, 1931. They grew from 17.74 mm to 38.4 mm in 12 months, an increase of 20.66 mm. When the amphioxus reached a length of 29.12 mm the gonads began to appear, and when they reached a length of 31.19 mm the gonads reached maturity. The records for 1931 were very much the same, except that the size was slightly greater in January.

Third-year amphioxus.—The second-year amphioxus of 1931 became the third-year individuals in 1932. They grew to a length of from 41.14 to 49.2 mm in this year, an increase of 8.06 mm. Some of the amphioxus of this age group spawned at the beginning of the year, and therefore had no enlarged gonads. However, most of them contained small gonads while many contained large gonads. In the middle of the year the amphioxus collected contained large gonads which were gradually discharged before the end of the year. The record obtained in 1931 was exactly the same as that for 1932.

Fourth-year amphioxus.—At the end of the third year all the gonads were discharged, and only a few of the individuals were able to live up to the beginning of the next year. These individuals were called the fourth-year amphioxus. They usually increased in length to 52.86 (1932) or 53 mm (1931), although one or two of them actually reached a length of 57 mm.

Old age of amphioxus.—Amphioxus were found to die from July of the third year to April of the fourth year. Since the young amphioxus were born continuously from June to the end of the year the life of amphioxus was from 2 to 3 years.

Seasonal distribution of different aged amphioxus.—The distribution of the different age groups of amphioxus in each month was quite interesting. The first-year amphioxus increased its percentage gradually from June (6.6 per cent) to the end of the year (8.7 per cent). The second-year amphioxus were not numerous in January (10.9 per cent), but gradually increased

up to the beginning of May (37 per cent), and suddenly increased at the end of May (72.7 per cent). The percentage continued to increase up to the end of the year (88.6 per cent). The third-year amphioxus were numerous in the beginning of the year (84.7 per cent) and decreased, as the second-year amphioxus increased, to 2.7 per cent by December. The fourth-year amphioxus were relatively few both in number of individuals and in percentage. All of them disappeared in April.

In short, the third-year amphioxus was predominant in the first part of the year, the second-year amphioxus was slightly predominant in the middle and predominant in the latter part of the year. The first-year and the fourth-year individuals were relatively few.

Growth and shape of amphioxus.—The shape of the young amphioxus is different from that of the adult. At a length below 20 mm the body is much broader in the pharyngeal region, and narrower at the posterior, and becomes narrower in the pharyngeal region in proportion and almost uniform in size from the anterior to the posterior end when it grows larger.

AMPHIOXUS FISHERIES

The phrase "amphioxus fisheries" was first introduced by Prof. S. F. Light. He described the fishing processes and published a few photographs. The present paper will give more detailed information about this industry, containing essentially the information contained in an article published in Chinese by the present writer and T. Y. Chen, and, in addition, many photographs relative to the processes of fishing amphioxus.

The history of amphioxus fisheries and the fishing ground were described in earlier parts of this paper; the present section covers the following: (*a*) fishing villages; (*b*) fishing equipment; (*c*) fishing processes; (*d*) fishing period; (*e*) annual production; (*f*) methods of cooking amphioxus; and (*g*) analysis and food value of amphioxus.

FISHING VILLAGES

Ten small fishing villages are present on the coast of the mainland, at Liuwutien and vicinity. About 7,300 inhabitants are scattered in these villages, of whom 610, representing 8.36 per cent of the total population, are engaged in fisheries. Among the fishermen 418 individuals, 68.52 per cent, are amphioxus fishermen, showing that this fishery is an important one in these villages. Usually two men are working on one

fishing boat, so that 209 fishing boats operate in this region. The distribution of the above records in the ten villages is given in Table 23.

TABLE 23.—*The villages, fishermen, and fishing boats engaged in amphioxus fisheries.*

Village.	Total population	Fishermen.	Amphioxus fishermen.	Amphioxus fishing boats.
Liuwutien	1,100	100	50	25
Pu Nang	900	150	100	50
Lu An	1,500	70	24	12
Nang Pien			28	14
Shan Tao			16	8
Hsu Tsu	1,700	200	24	12
Hoo Ping			132	66
Au Tsu	1,500	40	12	6
Chen Tsu	200	30	20	10
Kuei Yuan	400	20	12	6
Total	7,300	610	418	209

FISHING EQUIPMENT

The amphioxus fishing equipment is quite simple and primitive. It consists of (*a*) fishing boat, (*b*) dredge, and (*c*) washing apparatus.

Fishing boat.—The fishing boat is very much like an ordinary *sampan*, 18 feet long, 5 feet wide, 2.5 feet deep, 1.5 feet at the bow end, and 5 feet at the stem end. The capacity of the boat is about 1,000 pounds. Two sculls at the stem are 15 feet long. An elongated stone weighing more than 15 pounds, with a long cord attached, is used as a sinker. The boat, locally made, costs about 40 Chinese dollars, and lasts for 4 to 5 years.

Dredge.—The dredging apparatus may be divided into two kinds: light and heavy. Both are of the same style.

The lighter dredge consists of an iron scoop resembling a shovel blade and a bamboo stick, having a total weight of 7.3 pounds. The two sides of the scoop are each 12.5 inches long; the sharp edge is 13 inches and the base near the bamboo is 10 inches long. The bamboo stick, 8 feet and 2 inches long, is fastened to the base of the scoop at an angle of 75°. This lighter dredge is used only in very shallow water during ebb tide.

The heavier dredge consists of three parts; namely, an iron scoop, a bamboo stick, and a long cable consisting of two pieces of small rattan twined together. The two sides of the scoop

are each 14.5 inches long, the sharp edge being 17 inches, and the base 15.5 inches long. The bamboo stick is 12 feet 3 inches long, while the cable is 10 meters long. Between the bamboo stick and the scoop a short wooden stick is used to fasten them together, and sometimes another iron chain is also used between the scoop and the bamboo stick, thus securely holding the scoop. The cable is fastened to the other end of the bamboo. The bamboo stick is filled with sand to provide adequate weight to the dredge to sink to the bottom of the sea. This heavy dredge can catch amphioxus at any depth, even during the flood tide.

These apparatus can be used for 2 years. The lighter one costs 3 Chinese dollars and the heavier one, 6 Chinese dollars.

Washing apparatus.—Seven instruments are used for washing amphioxus. They are: (*a*) a bamboo floater about 3 to 4 cubic feet; (*b*) a round wooden plate, about 3 feet in diameter; (*c*) a bamboo bowl with a long handle; (*d*) two wooden blocks, 5 by 7 inches; (*e*) a small, deep, split-bamboo basket, 19 inches in diameter and 9 inches deep, with two small wooden handles on the sides; (*f*) a large, shallow, split-bamboo basket, 25 inches in diameter and 6.5 inches deep, also with two handles; and (*g*) a wooden vessel, about 10 inches in diameter.

FISHING METHODS

Upon reaching the fishing ground the boat is anchored by dropping the stone sinker, the cord of which is fastened to the side of the boat. The boat is thus prevented from drifting with the tide. Subsequently a bamboo floater with a wooden plate is put on the surface of the water on the other side of the boat. One of the fishermen holds a bamboo stick of the dredge at an angle of 45° to the holder (Plate 1, fig. 1). Then he throws the dredge on the surface of the water at an angle of 30° to 40° in front of the boat (Plate 1, fig. 2). When the scoop reaches the surface, it glides forward a little farther (Plate 2, fig. 1), increasing the towing distance on the ground. The trick is not easy for an ordinary man. The scoop can reach the sand by its own weight when towed slightly, otherwise a fisherman would have to propel the boat backward for a few feet in order to force the scoop into the sand.

When the scoop is about to be lifted, it is towed in the sand for a distance of 5 to 10 feet. Once the scoop is away from the sand, the fisherman strives to keep it in a horizontal position (Plate 3, fig. 1). The lifting process is very gradual, so that

the amphioxus cannot be washed away by the water. When the scoop is out of water the contents are quickly poured on the floating round board (Plate 3, fig. 2). These processess are repeated many times during the ebb tide, until enough amphioxus are collected.

The assistant fisherman, by means of the bamboo bowl, continuously washes (Plate 3, fig. 1) the sand away from the round board with sea water. When the water is poured on the surface of the sand, all the amphioxus burrow into the bottom of the sand; therefore only the surface sand is washed away into the sea. When most of the sand is washed away, the amphioxus on the board, with whatever amount of sand is left on them, are placed in the boat.

After sufficient amphioxus are captured, or when the tide is unfavorable for fishing amphioxus, the fisherman returns to the beach (Plate 4, fig. 1), where washing can be done more carefully.

The amphioxus and the sand are taken out of the boat with two wooden blocks into a small dip basket. (Plate 4, fig. 2). By rotating the basket on the surface of the water (Plate 5, fig. 1) the fine sand and the small amphioxus are made to pass through the bamboo slits into the water, until only the coarse sand, mollusks, and amphioxus are left. These are now transferred into a large bamboo tray for further separation. The bamboo tray is moved up and down and back and forth many times to cause the amphioxus to float to one side and the sand particles to sink to the bottom of the basket. Then the amphioxus are separated and placed into a wooden vessel for marketing.

THE FISHING SEASON

Young amphioxus float in the sea as planktonic organisms. On reaching maturity they migrate down and burrow into the sand, where they remain the rest of their lives. The fishing season begins between August and October. Numerous boats appear in the fishing grounds from December to January of the following year. The last period of the fishing season is from February to April, so that amphioxus fishing is carried on for 9 months of the year. The daily fishing period is limited by the tide, lasting 4 hours during receding tide.

It is fortunate that fishing for amphioxus is suspended during the breeding season, as this practice reduces the danger of depletion. During the breeding season the amphioxus do not taste

good, due to the lack of oil content, and, however, at this time the larger fishes and sharks, which have a higher market price, are available. Also, during this season the large majority of the people are busy in the rice fields.

ANNUAL PRODUCTION

The annual production of amphioxus is 55,845 catties or 74,460 pounds (35 tons), with a value of 11,727.45 Chinese dollars. This small sum represents a large income for these 10 small villages at Liuwutien and its vicinity. If one pound of fresh amphioxus, as estimated by Light, contains about 2,500 individuals, 1,526,430,000 individuals are captured for food annually.

The above figures are taken from weekly observations during 1932. The number of fishing boats and the market prices of amphioxus are shown in Table 24.

Table 24 shows the daily variation and monthly average of prices and boats. The maximum number of fishing boats in one day occurred in January, when 92 boats were observed. The daily average of 39.2 boats was observed in January and only 1 boat in June. The market price was from 16 cents to 32 cents Chinese currency per catty, and 21 cents per catty on the average.

No tax has been imposed on this industry. The average quantity of amphioxus captured by a fishing boat in one day is 10 catties. It is worth about 2 Chinese dollars, which is a good income for the natives.

The fishing markets are distributed in the fishing villages and in the Amoy market during the cold season. At Liuwutien there is only one old small amphioxus shop, the one shown in Plate 5, fig. 2. The amphioxus are also dried and sent to Java and Singapore for the emigrants from Amoy and its vicinity.

METHODS OF COOKING AMPHIOXUS

Amphioxus has no scale and no bone, and its internal organs need not be removed before cooking. The amphioxus must be washed with fresh water in order to reduce its salt content, and then cooked with egg, beef, or pork. The dried amphioxus are prepared above a small flame with a little oil in a pan. Fresh amphioxus may be kept for a long time. The dried amphioxus taste much better than the fresh. Dried amphioxus usually costs 1 Chinese dollar a pound.

TABLE 24.—*Market prices of amphioxus and number of fishing boats in 1932.*

Date.		Market price, in cents.		Number of fishing boats.	
		Each date.	Average for the month.	Each date.	Average for the month.
January	2	20	22.4	92	39.2
	9	28		8	
	16	22		54	
	22	22		18	
	29	20		24	
February	4	25	26.5	3	6.5
	11	24		5	
	18	32		3	
	25	25		15	
March	3	32	26.0	1	2.8
	10	22		10	
	17	----------		0	
	24	25		2	
	31	25		1	
April	7	25	25.0	3	6.5
	14	25		10	
May	5	----------	23.3	0	1.6
	12	22		4	
	19	25		2	
	24	22		2	
	27	----------		0	
	30	25		2	
July	14	----------	18.0	0	1.7
	23	18		2	
	25	----------		0	
	28	18		8	
August	1	20	17.6	10	5.8
	4	20		6	
	8	16		5	
	11	----------		0	
	15	----------		0	
	18	16		16	
	22	16		15	
	25	----------		0	
	29	----------			
September	1	18	19.2	12	27.8
	8	16		40	
	15	22		42	
	22	18		42	
	29	22		3	
October	6	22	20.0	50	27.5
	13	20		15	
	20	18		45	
	27	----------		0	

June	2	20		2					53		
	14			0					15		
	17			0					25		35.7
	20		19.0	0	1.0				31		
	23	18		5					35		
	27			0		November	6	18	35		
	30			0			10	18	30		
July	4		18.0	0	1.7		17	18	15	18.0	
	8			0			24	18	18		
						December	1	17			
							8	17			26.6
							15	17		17.8	
							22	22			
							29	16			

ANALYSIS AND FOOD VALUE OF AMPHIOXUS

The food value of amphioxus compares with that of other food fishes. It produces 1,859 to 2,122 lbs. / cals. per 100 grams. The fat content is rather low, but the iodine content of the fat is quite high. Protein is also high. The residue is quite high, three to four times that of ordinary fishes. Since the amphioxus are washed with sea water and then dried in the sun for analysis, foreign particles are usually mixed with the amphioxus, such as sodium chloride, potassium chloride, and silicon dioxide. Phosphorus is relatively low, while sulfate is relatively high, especially in the summer. Iron and calcium, which are very important in food fishes, are quite high.

The seasonal influence on amphioxus analysis is very much the same as in other fishes. The fat content is lower in summer, when the gonads of amphioxus are fully grown. The fat content is higher in the fall when the gonads are relatively small. Therefore people do not like to eat amphioxus in the breeding season, as I mentioned before. Residue and heat value are very much the same in different seasons. Table 25 gives a chemical analysis of Amoy amphioxus.

TABLE 25.—*Chemical analysis of Amoy amphioxus* (*Lau, 1934*).

Content.	For 100 grams of amphioxus.		Calculated from 100 grams of protein.	
	Summer.	Fall.	Summer.	Fall.
Humidity.....per cent..	7.85	11.56		
Heat value.....	21.22	18.59	29.66	26.88
Fat.....per cent..	2.12	3.98	2.98	5.75
Iodine value.....	106.60	101.6		
Protein.....grams..	71.16	69.18	100.00	100.00
Ash.....per cent..	14.45	13.79	20.31	19.93
SiO_2.....per cent of ash..	12.73	19.53	1.208	1.819
Fe_2O_3.....per cent..	4.74	5.28	0.673	0.736
CaO.....do....	2.75	3.72	0.399	0.530
MgO.....do....	4.48	4.03	0.549	0.485
SO_3.....do....	1.94	1.83	1.350	1.296
K_2O.....do....	13.53	16.33	2.281	2.703
Na_2O.....do....	28.91	24.54	4.355	3.629
Cl.....do....	29.82	23.74	6.054	4.729
P_2O_5.....do....	11.69	13.13	1.038	1.143

DISCOVERY OF QUAMOY AMPHIOXUS GROUND, IN THE VICINITY OF AMOY

Amphioxus was recently discovered at the north sea of Quamoy Island in the vicinity of Amoy. The grounds are irregular

in shape and rather small compared with those to the North of Amoy Island. Text fig. 18 shows the Quamoy amphioxus ground.

Twenty-seven samples were collected from this ground (about 1.5 square miles) and its vicinity. Sixteen of these samples were found to contain amphioxus. The conditions of the grounds are very much the same as those of the Amoy grounds.

The depth of these amphioxus grounds is from 0.5 to 3.5 meters, with an average of 1.9 meters. Therefore, these grounds are much shallower than the Amoy amphioxus grounds. The

FIG. 18. Map of Quamoy amphioxus ground, showing the station numbers.

number of individuals found at each station varies from 6 to 100, with an average of 54 individuals, which is less than that for Amoy. Since the amphioxus are so much less numerous the fishery is not developed and no people are interested in it. Table 26 shows data on bottom samples of the Quamoy amphioxus grounds, and Table 27 shows data for bottom samples collected from the vicinity of the Quamoy amphioxus grounds.

The origin of these amphioxus grounds is easily understood, since they are just outside of the Amoy amphioxus grounds. The larval and the postlarval stages of young amphioxus of

TABLE 26.—*Data on the bottom samples collected from the Quamoy amphioxus grounds.*

Station.	Depth.	Number of amphioxus.	Sizes of bottom particles.							
			Cannot be sifted through sieve 12.	Can be sifted through sieve—						
				12	18	30	60	90	100	120
	m.		cc.	cc.	cc.	cc.	cc.	cc.	cc.	cc.
1	1.0	37	400	250	175	340	50	4	2	4
2	1.0	79	325	210	175	425	57	2	2	5
3	1.0	51	120	200	230	560	32	2	1	5
4	1.5	74	225	255	450	260	30	2	2	4
5	0.5	11	375	240	160	410	28	2	1	7
6	2.0	70	60	160	330	575	20	2	1	4
7	2.5	50	6	140	320	625	25	2	1	5
8	3.0	6	75	150	340	550	52	10	5	12
9	1.0	54	40	160	340	600	20	1	1	3
10	2.0	40	35	130	350	600	17	2	1	4
11	3.5	16	40	160	375	570	28	5	2	5
12	1.5	13	225	365	385	50	23	8	2	8
13	3.5	100	130	300	375	350	32	8	4	7
14	2.0	100	28	217	300	435	45	5	3	10
15	1.0	78	33	240	420	413	30	6	2	4
16	3.0	86	39	200	340	533	20	7	3	4
Total	30.0	865	2,156	3,377	4,870	7,491	509	68	43	87
Average	1.8	54	135	211	304	468	31	4	3	5
Per cent			11.16	18.1	26.2	40.3	2.6	0.4	0.3	0.5

TABLE 27.—*Data on the bottom samples collected from the vicinity of Quamoy amphioxus ground.*

[No amphioxus were dredged from this ground.]

Station.	Depth.	Sizes of bottom particles.							
		Cannot be sifted through sieves 12.	Can be sifted through sieve—						
			12	18	30	60	90	100	120
	m.	cc.	cc.	cc.	cc.	cc.	cc.	cc.	cc.
17	2.0	400	80	105	280	24	7	6	340
18	1.3	600	100	90	200	70	3	5	300
19	4.0	75	430	120	175	70	10	10	450
20	4.0	100	190	245	205	28	1	1	500
21	5.0	138	350	205	140	43	6	9	370
22	3.0	5	75	180	880	30	4	1	9
23	4.3	85	310	619	145	80	3	3	7
24	3.0	100	213	345	450	23	4	2	23
25	3.5	75	190	290	70	91	2	2	600
26	6.0	275	250	100	270	50	6	5	450
27	10.0	260	210	285	300	70	7	6	360
Total	46.1	2,113	2,398	2,594	3,115	579	53	50	3,409
Average	4.2	192	218	236	283	53	5	5	310
Per cent		14.8	16.7	18.1	21.7	4.1	0.4	0.4	23.8

Amoy easily drift to the north of Quamoy. When the young amphioxus reach the Quamoy sand, they burrow in and reproduce there.

From this discovery we can expect that there will be more and more amphioxus grounds along the coast of Fukien and its vicinity, where the conditions are similar to those of the Amoy and Quamoy amphioxus grounds.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Fisherman holding his dredge in position before dredging. The town of Liuwutien is in the background.
2. Throwing the dredge at an angle of 45° to the boat.

PLATE 2

FIG. 1. The dredge gliding a little farther on the surface of the water. Crocodile Island is in the background.
2. The dredge reaches the bottom.

PLATE 3

FIG. 1. Lifting the dredge. The assistant fisherman is washing the amphioxus on the wooden disc.
2. Pouring the sand and the amphioxus on the wooden disc.

PLATE 4

FIG. 1. Fishing boats arriving at the beach.
2. Amphioxus and sand are put into the bamboo basket for separating.

PLATE 5

FIG. 1. Separating the amphioxus in a basket.
2. The amphioxus market at Liuwutien. The writer is buying a catty of fresh amphioxus.

TEXT FIGURES

FIG. 1. The regenerated tail.
2. The branched cirrus.
3. The abnormal gonads. *a*, lateral view; *b*, ventral view.
4. Map of Amoy and its vicinity, showing the currents in ebb tide (→), flood tide (→), and fresh water (→) from inland; the depth of the sea in meters; and the Amoy and Quamoy amphioxus grounds.
5. Map of Amoy amphioxus grounds, showing the station numbers and the fishing villages.
6. Map of Amoy amphioxus grounds, showing the distribution of the number of amphioxus in a 1,000 cc sand sample in each station.
7. Differences between bottom samples with and without amphioxus, collected from amphioxus grounds and their vicinity. 0 represents the largest particles of sand that cannot be sifted through sieve 12. 12, 18, 30, 60, 90, 100, and 120 represent particles that can be sifted through the corresponding sieve. 120 is the finest sieve.
8. Section of the sea from Chipbee through Crocodile Island to Liuwutien, showing the nature of the bottom and the distribution of amphioxus.

FIG. 9. Sections of the sea in the amphioxus grounds and their vicinity, showing depth and bottom conditions from which the directions of water currents are plotted.
10. Correlation between the large particles and carbon dioxide produced.
11. Temperature and dissolved oxygen content at Liuwutien in 1932.
12. Salinity and pH value at Liuwutien and Kulangsu; and rainfall at Amoy in 1932.
13. The vertical distribution of young amphioxus, and other related phenomena.
14. Growth of amphioxus in 1931 and 1932.
15. Rate of growth of amphioxus, expressed in logarithmic curve.
16. Growth of gonads in second-year and third-year amphioxus.
17. Different aged amphioxus in each month, in per cent.
18. Map of Quamoy amphioxus grounds, showing the station numbers.

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PLATE 1.

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PLATE 2.

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PLATE 3.

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PLATE 4.

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PLATE 5.

FILING AND BLACKENING OF TEETH AMONG SOME PHILIPPINE ETHNIC GROUPS

By Ricardo E. Galang

Of the Natural History Museum Division
Department of Agriculture and Commerce, Manila

TWO PLATES

This paper describes some of the methods of filing and blackening of the teeth, a practice adhered to by various Philippine ethnic groups. This odd practice may be due to a tribal conception of beauty or may merely be the continuation of an ancient means of preserving the teeth. Some of these groups, like the Bagobos, both file and blacken their teeth; the Negritos merely file them to points; while others, like the Kalingas, only blacken them.

The first part of the present paper deals with filing the teeth, while the second part deals with the method of blackening them.

FILING THE TEETH

Filing the teeth into points or filing their front surfaces concave was widely practiced formerly by nearly all of the known ethnic groups in the islands.

Worcester,[1] speaking of the filing of the teeth by the Negritos of Zambales, says that it is a widespread custom among this ethnic group to have the front teeth pointed. The operation is performed in the following manner: A piece of wood is placed back of the tooth to be operated on, the point of a bolo is firmly pressed against the front surface of the tooth, and the bolo is struck with a sharp blow with a stick or stone, so that the corner of the tooth is chipped off. This process is repeated on the other side of the tooth to produce the desired point.

According to Reed[2] the custom of filing the teeth prevails throughout the entire Negrito region of Zambales. Usually

[1] Worcester, Dean C. The Non-Christian tribes of northern Luzon. Philip. Journ. Sci. 1 (1906) 807.

[2] Reed, William Allan. Negritos of Zambales. In Ethnological Survey Publications pt. 1 2 (1904) 36.

only the upper teeth are treated. However, there were cases where the teeth were sharpened both above and below. Adornment seems to be the sole object of this practice.

The sharpening of the teeth is performed by placing the blade of a bolo against the part of the tooth to be chipped off and giving it a sharp blow with a piece of wood. The operation is locally known as *talihan*. It is a rather delicate process, for it requires care to prevent breaking through into the soft part of the tooth and exposing the nerve. Although the teeth are mutilated, they seem to be well preserved.

Cole [3] states that both men and women of the Bagobos on the west coast of Davao Gulf file their teeth. When a boy or girl has attained puberty, it is time to beautify the teeth. There is however, no prohibition from having it done earlier. The patient places his head against the operator and grips a stick of wood between his teeth while each tooth is filed to a point. (Plate 1, fig. 1) When this operation has been completed what is left is blackened.

According to Christie [4] it is very common among the Subanuns of Sindañgan Bay to grind down some of their teeth. The teeth selected are the upper front teeth, including the two canines. The effect aimed at is the sharpening of the latter and the hallowing out on the anterior surface of the former so as to produce a concave appearance. The grinding is done with a stone. There is no fixed period for the process of grinding, but it is usually done when the patient is well grown. The grinding is done gradually. The teeth operated on are commonly blackened after grinding.

According to Garvan,[5] among the Manobos both boys and girls have their teeth ground at puberty. The process of grinding the teeth is very simple but extremely painful. A piece of wood is inserted between the teeth to keep them apart. The operator then inserts a small piece of sandstone into the mouth, and with a moderate motion grinds the upper and lower incisors to the gum. After filing, the teeth of the upper jaw appear convex and those of the lower, concave. It takes 3 to 10 days to grind the teeth.

[3] Cole, Fay-Cooper. The Wild Tribes of Davao District, Mindanao. In Field Museum of Natural History (2) 12 (1913) 60.

[4] Christie, Emerson Brewer. The Subanuns of Sindañgan Bay. In Division of Ethnology Publications pt. 1 6 (1909) 52, 53.

[5] Garvan, John M. Mem. Nat. Sci. 23 (1931) 55.

Colin [6] says that "the ethnographic groups who are now civilized formerly had the custom from infancy to file their teeth so that they may be even and pretty."

Bobadilla [7] states that "among the Bisayans, the teeth were filed from their earliest childhood. Some were made even, and others were filed to points which give them the appearance of a saw."

Chirino [8] also says that "among the Bisayans, the teeth were filed and sharpened from early childhood either leaving them uniform or fashioning them all to a point, like a saw. This matter was not practiced by the higher class of people."

Morga [9] states that among the Sambals the teeth were filed and made even with stone and iron from a very early age.

BLACKENING THE TEETH

The practice of blackening the teeth likewise was formerly widespread, although the Negritos and a few other pagan groups of northern Luzon do not follow it. The majority of the pagan and Mohammedan groups of Mindanao, however, generally blacken their teeth, to beautify and preserve them.

Although among a good number of Kalingas this custom is obsolete, there are still a few, particularly those living in the outlying districts, who adhere to it. Among males teeth-blackening is usually done at the age from 14 to 21; among the females, usually at puberty. Like the other groups, the Kalingas blacken the teeth to beautify and preserve them.

The material used is the black resinous substance from dried guava bark, burnt and rubbed against the *landuc* or *babalasigan,* an iron implement where the substance is accumulated. Before the subject retires, the black resinous substance is heated and rubbed with the fingers on the teeth until they are en-

[6] Colin, Francisco. Native Races and their Customs. In Blair, Emma Helen, and James Alexander Robertson. The Philippine Islands 1493–1898. 40 (1906) 60, 61.

[7] Bobadilla, Diego de. Relation of the Filipinas Islands. In Blair, Emma Helen, and James Alexander Robertson. The Philippine Islands 1493–1898 40 (1904) 287.

[8] Chirino, Pedro. Relation of the Filipinas Islands. In Blair, Emma Helen, and James Alexander Robertson. The Philippine Islands 1493–1898 40 (1904) 187.

[9] Morga, Antonio de. Sucesos de las Islas Filipinas. In Blair, Emma Helen, and James Alexander Robertson. The Philippine Islands 1493–1898 16 (1904) 78.

tirely black. Because of the unpleasant taste of this blackening agent, it is not widely used and has fallen into disfavor. This practice is usually observed at least once a week, or as often as the black color of the teeth fades. This method of blackening is known as *tubug* among the Mañgali-Lubo group, and as *beasig* among the Lubuagan groups.

Cole,[10] who made a study of the Tinggians of Abra, states that both men and women blacken the teeth with iron salts and tan bark.

De los Reyes, speaking of the Tinggians of Abra, says that "Los Tinguianes se tiñen de negro los dientes."[11]

According to Cole [12] the color for blackening the teeth of the Bagobos is obtained in two ways. The common method is to place a piece of metal on one end of a bamboo tube, made of a variety of bamboo known as *balakáyo*, with one end resting on glowing coals. The smoke from the charring bamboo is conducted through the tube to the metal on which it leaves a deposit or 'sweat.' This is rubbed on the teeth, at intervals, until they become shiny black.

In a second method a kind of powder, known as *tapel*, is used. Tapel is secured from the *lamod* tree. The powder is wrapped in leaves and chewed. During this period of treatment the patient is under certain restrictions. He is not allowed to drink water, cook, or eat anything sour. He should not attend funerals. Should he do so, his teeth will have a poor color or he himself will be sick. When the teeth have been properly blackened the young man or woman is considered ready to enter society.

According to Garvan,[13] among the Manobos blackening of the teeth is effected principally by the use of a plant called *máu-máu* which, besides being used as a narcotic, has the property of giving the teeth a rather dark color. After being chewed it is rubbed across the teeth to make the coloring uniform. The

[10] Cole, Fay-Cooper. The Tinggian. Philip. Journ. Sci. § A 3 (1908) 201.

[11] De los Reyes y Florentino, Isabelo. Articulos Varios (1887) 10.

[12] Cole, Fay-Cooper. The Wild Tribes of Davao District, Mindanao. In Field Museum of Natural History Publications 12 (1913) 60, 61.

[13] Garvan, John M. Mem. Nat. Acad. Sci. 23 (1931) 55.

constant use of betel leaf with lime is another means of staining the teeth.

Christie [14] says that after the teeth of the Subanuns are ground even, it is a common practice to blacken them. One substance used for this purpose is lime juice or some other acidic liquid in which iron has been allowed to dissolve. The resultant solution is rubbed on the surface of the teeth. There is no fixed period for the process of staining, but it may be said to be usually done when the patient is well grown.

Blackening of the teeth is practiced very extensively among the Sulu Moros. The teeth are dyed black with antimony, a mineral stibnite.

Bobadilla [15] states that the ancient Bisayans covered their teeth with either a black, or a flame-colored, glossy polish. Thus their teeth become black or vermillion red, as the case may be. Small openings are made in the upper row, which are filled with gold which shows to advantage on the black or red background of the polishing material.

According to Chirino [16] the ancient Bisayans covered their teeth with varnish, either lustrous black or bright red, with the result that the teeth remain as black as jet, or ruby or vermillion red. From the edge to the middle of the tooth they neatly bore a hole, which they afterward fill with gold, so that this point of gold remains as a shining spot in the middle of the black tooth. Teeth treated in this manner are regarded by them as a mark of beauty.

SUMMARY

The practice of filing the teeth was formerly almost universal among ethnic groups in the Philippines. The practice has now lost favor, but a few tribes still adhere to it, among them the Negritos, Bagobos, Manobos, and Subanuns.

[14] Christie, Emerson B. The Subanuns of Sidañgan Bay. In Division of Ethnology Publications pt. 1 6 (1909) 52, 53.

[15] Bobadilla, Diego de. Relation of the Filipinas Islands. In Blair, Emma Helen, and James Alexander Robertson. The Philippine Islands 1493–1898. 29 (1904) 287, 288.

[16] Chirino, Pedro. Relation of the Filipinas Islands. In Blair, Emma Helen, James Alexander and Robertson. The Philippine Islands 1493–1898. 22 (1904) 187.

Likewise the practice of blackening the teeth was formerly widespread. Some pagan groups of northern Luzon—the Kalingas and Tiñggians and the majority of the pagans and Mohammedans of Mindanao—Bagobos, Manobos, Subanuns, and Sulu Moros—cling to the custom with stubborn tenacity.

The idea of filing and blackening of the teeth may be due to an endemic conception of beauty or may be merely a perpetuation of an ancient type of dental prophylaxis.

ILLUSTRATIONS

PLATE 1

FIG. 1. A Bagobo young man having his teeth filed or cut to points.
2. A Bagobo man showing his pointed upper teeth.

PLATE 2

FIG. 1. A Negrito man from the mountains of Pampanga, showing his pointed teeth.
2. A Moro datu of Jolo, showing his blackened teeth.
3. Iron instruments (babalasigan) used by the Kalingas in blackening the teeth.

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PLATE 1.

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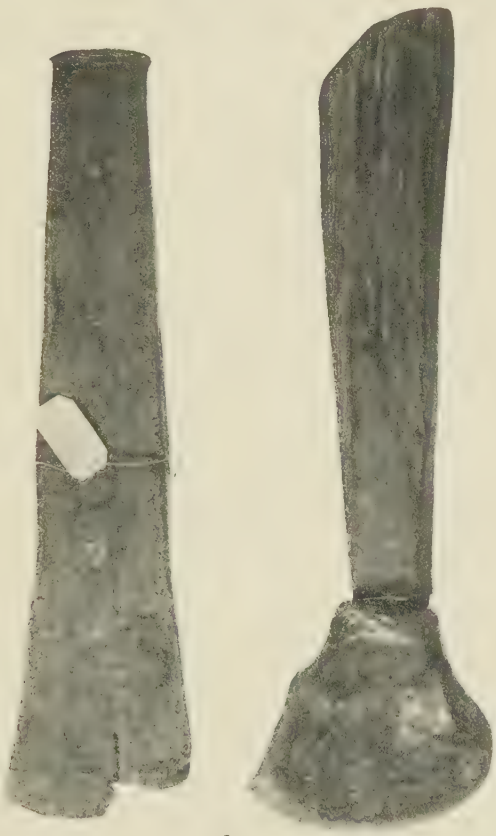

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PLATE 2.

BOOKS

Books reviewed here have been selected from books received by the Philippine Journal of Science from time to time and acknowledged in this section.

REVIEWS

Race, Language and Culture. By Franz Boas. New York, The Macmillan Co., 1940. 647 pp., illus. Price, $5.

Race, Language and Culture is a recent anthropological work, composed of the author's collected writings, dealing principally with the physical and social aspects of anthropology. It is divided into the three main topics indicated by the title. Also appended are miscellaneous topics on the methods of teaching anthropology, the aims of ethnology, and the study of geography.

In his chapters on race the author refers to biological and sociological problems due to the intermingling of racial types. He dwells on the modern population of America and its heterogeneity, on heredity, on the influence of environment, on selection, on racial and individual differences, and on eugenics. He formulates problems and proposes investigations. He also discusses the anthropological study of children and the study of anthropometry. His main object is to determine how the physical development of a given individual compares with the average physical development of the group to which he belongs. There is also included a critical review of the works of authors dealing with the methods of physical anthropometry.

The author devotes a goodly number of pages to the study of American aboriginal languages and their classification. He particularly mentions some characteristics of the Dakota languages and the metaphor of the Kwakiutl tribe. He gives a brief exposition of facts relative to the aims of anthropological research and the methods of cultural anthropology. He likewise discusses the origin of totemism, the history of the American race, ethnological problems in Canada, the social organization of the Kwakiutl society and North Pacific Coast tribes, the development of folktales and myths, the growth of Indian mythologies, and the idea of future life among primitive tribes.

He advocates the inclusion of anthropology in the University curriculum and sets forth the aims of ethnology. He discusses the total range of the phenomena of social life. The last topic treats of the value of geography in research.

In this book the author gives, in clear, concise form, a freer and more independent view of the study of man. He cites, too, the relation which such study bears to everyday problems.

Every student of anthropology should read this book.

—R. E. G.

Chemistry in Warfare; Its Strategic Importance. With a Foreword by Crosby Field and a Technical Appendix. By Frederick A. Hessel, M. S. Hessel and W. J. Martin. New York, Hastings House, 1940. 164 pp., illus. Price, $2.

This book is so far the latest work on the rôle of chemistry in warfare, including the present world conflict. It contains valuable information for the enlisted man, the chemist, and the layman. It gives a vivid picture of how wars are fought at the front, in the factories, and in the research laboratories. It explains why no nation today can afford to be without an active chemical industry and chemists equipped to meet any emergency.

It illustrates the rôle of the chemist in keeping an army in fighting condition by the proper supply of food, clothing, and shelter. It explains how weapons, both defensive and offensive, are adequately supplied with projectiles, propellants, and high explosives. It tells how troops, as well as civilians, are fitted out with gas masks and other protective equipment.

It gives a brief but nevertheless thorough outline of the development of modern armaments. The information obtained from this books enables the layman to understand the technical names of poison gases, explosives, and other military equipment about which he reads daily in the newpapers.

The book is divided into five chapters. It contains an appendix on the technical processes used in the manufacture of the principal war materials. It also contains a selected bibliography on the subject.—F. A.

Chemicals of Commerce. By Foster Dee Snell and Cornelia T. Snell. New York, D. Van Nostrand Co., Inc., 1939. 542 pp. Price, $5.

Many books have been written that deal with chemistry and chemicals for the layman. Chemicals of Commerce is one of the books that deserves special attention. Thirty-seven chapters cover all the chemicals most frequently used in commerce. The grouping of allied chemicals by chapters gives the reader a

bird's-eye view of the different products included without resorting to other references. In the appendices are included: The United States Caustic Poison Act; Summary of the Food, Drug and Cosmetic Act; and definitions of medical terms used in the book.

The authors should be commended for putting into book form and in simple language a great deal of information about formulas, uses, and properties of chemicals that is usually available only to a selected group of chemists.

Written in a popular style, the book is very useful and should be on the bookshelf of those engaged in chemistry and others who seek information about the thousand and one chemicals of commerce.—G. O. O.

May's Chemistry of Synthetic Drugs. By Percy May and G. Malcolm Dyson. Fourth Edition, Revised and Rewritten. London—New York —Toronto, Longmans, Green and Co., 1939. 370 pp., illus. Price, $6.

As stated in the preface, this book contains an account of the main facts concerning the nature of synthetic drugs and the guiding principles which are used in their production.

It also calls attention to reactions taking place between the drug and the living organism whenever these can be traced. Consideration is also given to the relation between the chemical character of a substance and its pharmacological action, even though this relation is neither so complete nor so simple as might be desired.

Included in this new edition are the recent advances in the chemistry of hormones, vitamins, sulfonamide derivatives, synthetical ureas, and organometallic compounds.

This book is standard in the line of synthetic drugs, and the fourth edition is characterized by the same excellence as the former editions.—A. O. C.

Chemotherapy and Serum Therapy of Pneumonia. By Frederick T. Lord, Elliott S. Robinson, and Roderick Heffron. New York, The Commonwealth Fund, 1940. 174 pp., illus. Price, $1.

This little book is in the main a description of the work done by the Massachusetts Department of Public Health. The presentation of the facts, the arrangement of the topics, and the principal purpose seem to be to furnish the general practitioner with a manual to guide him in the treatment of pneumococcus pneumonia.

A few paragraphs are devoted to the discussion of pneumonia as a community problem, to definitions, and to diagnosis. The

greater part of the book is given to data about the use of sulfapyridine and of immune serum. Detailed information about the indications of these two therapeutic aids, the contraindications, the manner of administration, the posology, and the untoward reactions and their treatment are given. In appendix C an instruction sheet intended for physicians regarding the use of sulfapyridine and antiserum is attached. The sheet gives a summary of when to use the drug alone, when to use the serum alone, and when to use both. The manner of adjusting dosage, the warnings about toxic manifestations, and when to discontinue serum therapy are indicated.

Various other procedures necessary in the treatment of pneumonia, and which the general practitioner can make use of, are also discussed in detail. The Neufeld method of typing, the Francis skin test, the different tests for sensitivity, and the step by step directions for administering serum are also described.

A comparison of the results obtained with the two ways of treating pneumonia is made. But the different tables and figures are now somewhat out of date because so rapid and widespread has been the use of the different sulfanilamide compounds that the results of different workers published in journals quickly supersede those found in books, even if these be only a few months old. The book is not intended for the research worker or investigator, because the author has not brought out anything new or provocative. It is primarily for the use of the practitioner who would like a manual of instructions that is practical, brief, and comprehensive.—A. B. R.

Photo-Lab-Index. The Cumulative Formulary of Standard Recommended Photographic Procedures. By Henry M. Lester. New York City, Morgan & Lester, 1939. 288 pp. Price, $3.50.

Photo-Lab-Index is a compilation of the old and the new findings in the science of photography. It is a sort of a photo vocabulary for the amateur and professional photographers. Being very handy as a reference, this book will help a great deal in understanding the new and modern methods employed in photography. Different photo manufacturers are publishing quarterly improvements of their film papers and formulas for developers. Workers in photography should be well informed in the new procedures so as to keep them abreast of the modern trend in photography.

This book is highly recommended to anyone interested in photography.—C. S. A.

Conserving Our Resources. By Edward E. Keso. Oklahoma City, Times-Journal Publishing Co., 1940. 206 pp., illus. Price, $0.98.

This book is a handy, comprehensive volume, written in popular style, on the conservation of natural resources. It seems primarily intended for use in schools below the collegiate rank and, although the discussions generally refer to American resources and conditions, it will be a very valuable reference book in all of our school libraries. It will relieve us who are actually and actively engaged in the work of administering, developing and conserving our own natural heritage, of much of the educational phase of conservation. Thus we shall be able to concentrate our attention on the tasks of solving the numerous problems that arise from the growing demands of our population upon these resources, and of prolonging, for an indefinite length of time, their availability for prudential use.—S. S. P.

Aids to Goatkeeping. By Corl A. Leach. Third edition. Fairbury, Nebraska, Dairy Goat Journal, 1940. 104 pp., illus. Price, $1.

To the beginner in the raising of dairy goats this book will prove an interesting and valuable reference. Written in simple, concise language, it contains suggestions in choosing a breed; in housing, caring, feeding, and managing does, bucks, and kids. It contains some illustrated descriptions on the proper way to construct dairy goat barns and milk houses, as well as other facilities needed in a dairy goat project.

As in the cattle dairy, the procuring of clean, safe, sanitary milk and the keeping of production records are emphasized in this book. The causes of ill-flavored milk and the means to preclude or avoid them are given.

Udder troubles, ailments, and parasites commonly observed in goats are treated lengthily in this book. The author enumerates in plain terms the most common symptoms of these maladies, and simple remedies for eradicating them. He emphasizes the need of consulting a qualified veterinarian, whenever available, in handling these diseases.

Finally, the author states that "there is no greater aid to goat keeping than the common sense of the goat keeper." In order to succeed, he suggests that a goat keeper should keep a vigilant eye on the needs of the animals; exercise his careful judgment and consideration in the application of suggestions and instructions; come in contact with and consult other goat owners; and avail himself always of the benefits derived from

the study of periodicals and writings of others pertaining to the dairy goat.—G. S. A.

Principles of Dairy Goat Selection. By Corl A. Leach. Fairbury, Nebraska, Dairy Goat Journal, 1940. 56 pp., illus. Price, $1.

The books is an exposition of the principles underlying the selection of dairy goats, on the basis of type, production, and pedigree. The author claims that very few goats possess pedigrees or papers of registry, and for this reason lays emphasis on selection based on type. A discussion on the relationship of form to production is given in detail. Score cards for judging the utility goat and the most important breeds of dairy goats are also included. Illustrations form part of the text. As the author puts it, "the principles outlined herein are but principles . . . Should any breeder consider the suggestion given here as final and conclusive, the book will not only lose its value but can defeat its own purpose. But if regarded as a guide book, explaining the signs where-by the breeder can proceed as his own judgment dictates, then these principles will become a practical guide to increasing the excellence of the breed."

—G. S. A.

1940 Yearbook of the American Goat Society, Incorporated. University Place Station, Lincoln, Nebraska, The Society, 1940. 237 pp., illus. Price, $1.

The yearbook contains a history of the American Goat Society, Incorporated. It contains splendid articles on dairy goats such as, Why a Purebred Sire? by Ira J. Mills, Twenty-Five Years With Purebred Goats by W. D. Stambaugh, Artificial Insemination in Goats by L. M. Winters, and others by well-known authors. It also includes the Constitution, The Bylaws, Rules, and Regulations of the American Goat Society. Registration of some of the most popular breeds of dairy goats, such as the French Alpine, Nubian, Saanen, and Toggenburg forms part of the yearbook. It is profusely illustrated, and ably edited by Will H. Chappel, President of the American Goat Society, Incorporated.—G. S. A.

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Bishop, Ggrace M. You and your food. London, The C. W. Daniel co., ltd., 1939. 45 pp. Price, paper, 1s/–.

Brough, James. The triassic fishes of Besano, Lombardy. Printed by order of the trustees of the British Museum, London, 1939. 117 pp., plates, illus. Price, £1.

FRAPRIE, FRANK R., ED. How to make lantern slides. Practical photography, no. 7. Boston, American photographic publishing co., 1940. 80 pp., illus.

HAWKINS, HAROLD F. Applied nutrition. Gardena, California, Institute press, 1940. 195 pp., illus. Price, $3.

JACOBSON, C. I. Developing: the negative technique (Manual of phototechnique, no. 2). London and New York, The focal press, 1940. 287 pp., llus. 10s/6d.

MARBLE, PRISCILIA R. Home safety. New York, American book co., 1940. 144 pp., illus. Price, $0.80.

READ, BERNARD E., and W. WAGNER. Shanghai vegetables. Shanghai, The China-Journal publishing co., ltd., 1940. 31 pp., plates.

SMITH, KENNETH M. The virus: life's enemy. New York, The Macmillan co. Cambridge: At the university press, 1940. 176 pp., illus., front. Price, $2.

ERRATA

VOLUME 74, No. 3

Page 247, last paragraph, line 6: *For* on *read* one.

Page 258, caption of Table 5 should read: *Effect of the time of contact of grated coconut meat with water on efficiency of oil extraction*—continued.

Page 275, line 15 should read: One gas producer engine, 250 H. P., with motor.

VOLUME 75, No. 2

Illustrations of the article "Notes on the orchid bug, Mertila malayensis Distant, on white mariposa (Phalaenopsis amabilis Blume)," by Santiago R. Capco: *For* Plate 1 *read* Plate 2, and *for* Plate 2 *read* Plate 1.

According to a letter received September 12, 1941, from Prof. H. H. Knight, of Iowa State College, the orchid bug described in Capco's article is *Mertila brevicornis* Poppius (Tijdschr. v. Ent. Suppl. 56 [1914] 154) and not *Mertila malayensis* Distant.

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